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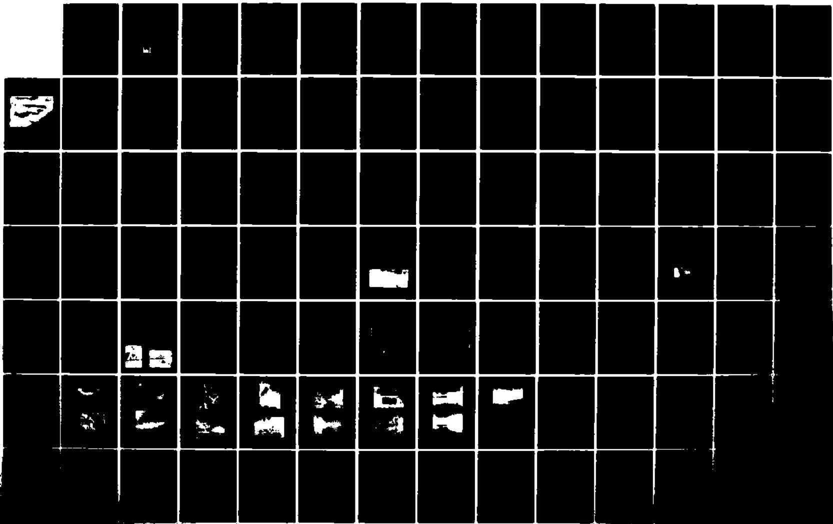

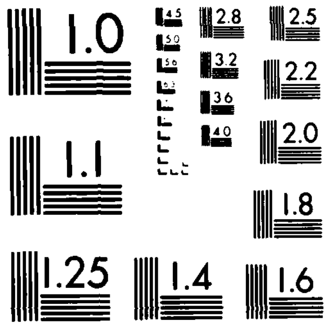

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AD-A156 476

MERRIMACK RIVER BASIN

CONCORD, NEW HAMPSHIRE

ST. PAULS SCHOOL DAM

NH 00361

NHWRB NO. 51.25

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

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REPORT DOCUMENTATION PAGE

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
Concord New Hampshire
Turkey River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is a concrete overflow section about 15 ft. high with a length of 100 ft. The dam is in fair condition at the present time, with a few major concerns which must be corrected. The size is intermediate with a significant hazard potential. The dam could be damaged by the discharge over the abutments. It is not anticipated that lives would be lost.

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REPLY TO
ATTENTION OF:
NEDED

JUN 19 1980

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

Inclosed is a copy of the St. Pauls School Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, St. Pauls School, Concord, New Hampshire 03301.

Copies of this report will be made available to the public upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

ST. PAULS SCHOOL DAM
NH 00361
NHWRB 51.25

MERRIMACK RIVER BASIN
CONCORD, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No:	NH 00361
Name of Dam:	St. Pauls School Dam
Town:	Concord
County and State:	Merrimack, New Hampshire
Stream:	Turkey River
Date of Inspection:	February 5, 1980

St. Pauls School Dam is a concrete overflow section approximately 15 feet high from the bottom of the upstream channel to the top of the training walls and approximately 100 feet long between the training walls. The upstream face of the concrete overflow section is vertical and measures approximately 9 feet from its crest to a concrete apron on the channel bottom. The downstream face is ogee shaped and measures approximately 11 feet from its crest to a concrete apron on the bottom of the downstream channel.

The dam impounds Little Turkey Pond and adjoining Turkey Pond. The discharge over the spillway flows through the Turkey River in an easterly direction for approximately 0.2 miles to the upstream end of an unnamed pond located on the western side of the St. Pauls School Campus. The purpose of the dam is recreational. The reservoir is 2.65 miles in length with a surface area of about 360 acres. The maximum storage capacity is about 6,410 acre feet.

As a result of the visual inspection and the review of available data regarding this facility, the dam is considered to be in FAIR condition. Major concerns are: lack of vegetation on the crest of both abutments render these areas less resistant to erosion; seepage discharge over the top of the low training walls on both sides of the discharge channel immediately below the dam; small trees growing on the downstream slope of both abutments; and leakage of the sluice gate.

This dam is classified as INTERMEDIATE in size and a SIGNIFICANT hazard structure in accordance with the recommended guidelines established by the Corps of Engineers. The test flood for this dam, therefore, ranges from one-half the Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). The full PMF was utilized for this hydrologic analysis. The test flood inflow was estimated to be 38,400 cfs, and resulted in a routed test flood outflow equal to 17,200 cfs which would overtop the dam crest by about 6.0 feet. The maximum spillway discharge capacity with the water level at the dam crest was estimated to be 5,660 cfs or about 33 percent of the routed test flood outflow.

Since the tailwater resulting from discharge over the spillway, with the water surface at top of training walls, would increase the stage in the downstream reaches nearly as much as the dam failure discharge, the hazard potential for this dam was assessed by failing the dam with the water surface at the crest of the spillway. The discharge from this failure would raise the water surface in the lower pond by nearly 4 feet. Water would enter one classroom to a level of 1 to 2 feet above the sill, and would result in damage to the lower floor. The dam creating the lower pond could be damaged by the discharge over the abutments. It is not anticipated that lives would be lost.

It is recommended that the owner engage a qualified registered engineer to specify erosion protection for the soil abutments, investigate the seepage discharging over the top of the low training walls on both sides of the discharge channel immediately below the dam, investigate the leakage of the sluice gate and do a detailed hydrologic-hydraulic investigation to assess further the potential of overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity. It is also recommended that the owner remove the trees from the immediate vicinity of the dam and downstream channel, repair all spalled concrete and control trespassing on the abutments.

The recommendations and remedial measures are described in Section 7 and should be addressed by the owner within one year after receipt of this Phase I Inspection Report.

THE STATE OF NEW HAMPSHIRE
KENNETH M. STEWART
NO. 3531
REGISTERED
PROFESSIONAL ENGINEER

Kenneth M. Stewart

Kenneth M. Stewart
Project Manager
N.H.P.E. 3531

S E A Consultants Inc.
Rochester, New Hampshire

This Phase I Inspection Report on St. Pauls School Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Aramast Mahtesian

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Richard J. DiBuono

RICHARD DIBUONO, CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and

rarity of such a storm event, finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespassing and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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OVERVIEW PHOTO - ST. PAULS SCHOOL DAM

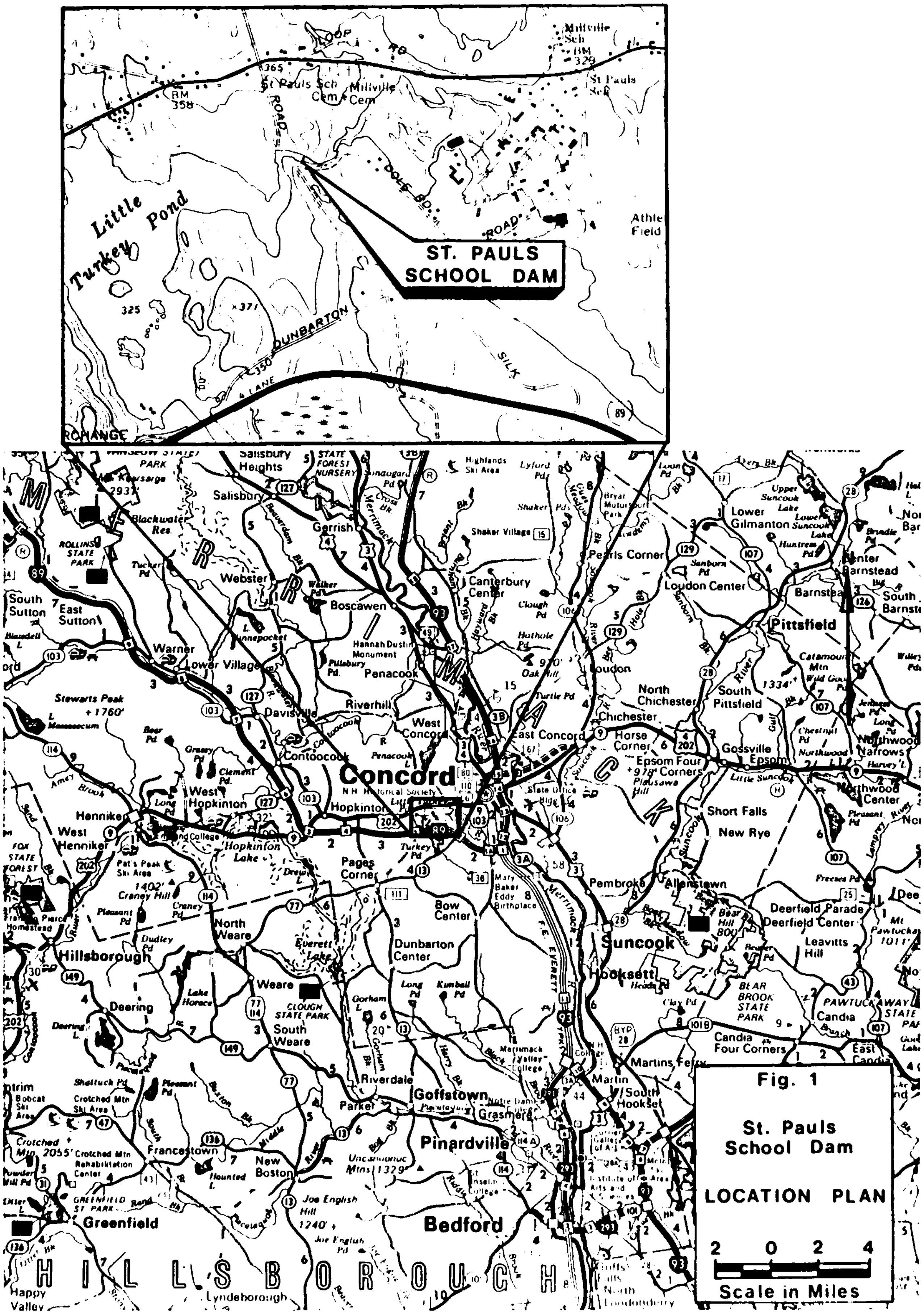


Fig. 1

St. Pauls School Dam

LOCATION PLAN

2 0 2 4

Scale in Miles

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
ST. PAULS SCHOOL DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. S E A Consultants Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to S E A Consultants Inc. under a letter of November 5, 1979 from William Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0008 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. St. Pauls School Dam is located in the City of Concord, New Hampshire, on the northeast corner of Little Turkey Pond. The dam impounds water from Little Turkey Pond and adjoining Turkey Pond. Water passing over the spillway, flows in an easterly direction through the Turkey River approximately 0.20 miles to the upstream end of an unnamed pond on the western side of the St. Pauls School Campus. The dam is shown on U.S.G.S. Quadrangle, Concord, New Hampshire, with coordinates approximately at N43^{o}11'35", W71^{o}35'21", Merrimack County, New Hampshire (see Location Plan).

b. Description of Dam and Appurtenances. St. Pauls School Dam is a concrete overflow section approximately 15 feet high from the bottom of the upstream channel to the top of the training walls, and approximately 100 feet long between the training walls. The upstream face of the concrete overflow section is vertical and measures approximately 9 feet from its crest to a concrete apron on the channel bottom. The downstream face is ogee shaped and measures approximately 11 feet from its crest to a concrete apron on the bottom of the downstream channel.

Located through the overflow section near the right training wall is a sluiceway which consists of a 36 inch diameter pipe controlled by a sluice gate located on the upstream end of the sluiceway pipe.

c. Size Classification. Intermediate (height - 15 feet; storage - 6,410 acre-feet) based on storage (greater than or equal to 1,000 acre-feet and less than 50,000 acre-feet) as given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. Significant Hazard. The discharge resulting from failure of the dam, with water surface at the spillway crest, would raise the water surface of the lower pond by nearly 4 feet. Water would enter one classroom building to a level of 1 to 2 feet above the sill, causing damage to the lower floor of this building. Water would also flow over the two roadways crossing the lower pond, possibly causing damage to the roadways and bridges. In addition to this, the dam creating the lower pond could be damaged by the 4 feet deep flow over its abutments. It is not anticipated that lives would be lost.

e. Ownership. St. Pauls School Dam was completed in 1958 and has been continually owned by St. Pauls School, Pleasant Street, Concord, New Hampshire 03301. Telephone No. (603) 225-3341.

f. Operator. The dam is maintained and operated by St. Pauls School, Pleasant Street, Concord, New Hampshire 03301. Telephone No. (603) 225-3341.

g. Purpose of Dam. The dam was constructed to raise the level of Turkey Pond in order to build a rowing course for St. Pauls School.

h. Design and Construction History. The dam was designed by Lockwood, Kessler, and Bartlett, Inc., Consulting Engineers, Syosset, New York, in 1957. Construction began that same year by Manchester Sand, Gravel and Cement Company, Inc. Bow, New Hampshire and was completed in 1958. The design plans indicate that sections of the concrete dam are reinforced and built on an earth foundation. The plans and borings are on file at the State of New Hampshire Water Resources Board. A copy of the specifications was obtained from St. Pauls School, who also has a set of plans. A set of plans and specifications dated 1946 and prepared by Metcalf and Eddy, Engineers for the design of St. Pauls School Dam is also on file at the State of New Hampshire Water Resources Board. This design was never implemented in favor of the Lockwood, Kessler, and Bartlett design of 1957. The borings made in 1946 for Metcalf and Eddy were used in the final design and construction by Lockwood, Kessler, and Bartlett. No in-depth design calculations or as-built drawings were disclosed for this dam.

i. Normal Operating Procedures. The St. Pauls School Dam is used to retain the waters of Little Turkey Pond and adjoining Turkey Pond in order to provide a rowing course for St. Pauls School. There is no normal operating procedure for this dam.

1.3 Pertinent Data

a. Drainage Area. The drainage area above the St. Pauls School Dam covers nearly 29 square miles (approximately 18,560 acres), consisting of moderately sloping terrain surrounding a broad swampy area adjacent to Turkey Pond. The topography in the drainage basin ranges from over 880 feet (NGVD) on top of Brown Hill to approximately 316 feet (NGVD) at the base of the dam. The majority of the basin is heavily wooded and numerous houses are located along the roadways which transect the drainage area.

b. Discharge at Damsite. Discharge at the damsite occurs over the 100 feet long ogee shaped overflow section. A 36 inch diameter sluiceway extends through the core of the overflow section near the right training wall and has its invert set approximately 8 feet below the overflow weir crest. The sluice gate located on the upstream end of the sluiceway pipe would allow the ponding area to be lowered to an elevation of about 317 feet (NGVD).

(1) The capacity of the sluice gate was estimated to be 480 cfs with the water surface at the top of dam (Elev. 331.0 feet) and 585 cfs with the water surface at the test flood elevation (Elev. 337.0 feet).

(2) Maximum known flood at damsite - unknown

(3) The ungated spillway capacity with the water surface elevation at the top of the dam (elevation 331.00 feet) was estimated to be 5,660 cfs.

(4) The ungated spillway capacity with the water surface elevation at the test flood elevation (elevation 337.0 feet) was estimated to be 16,200 cfs.

(5) N/A

(6) N/A

(7) The total spillway capacity at the test flood elevation was estimated to be 16,200 cfs at 337.0 elevation.

(8) The total project discharge at the top of the dam was estimated to be 5,660 cfs at 331.0 elevation (with the sluice gate closed) and 6,140 cfs at 331.0 elevation (with the sluice gate open).

(9) The total project discharge at the test flood elevation was estimated to be 17,200 cfs at 337.0 elevation.

c. Elevation (NGVD) These elevations are based on a pool elevation of 325.0 shown on the Concord Quadrangle U.S.G.S. sheet, which was assumed to be the pool elevation at the crest of the overflow section. It should be noted that a 6.0 foot discrepancy exists between the U.S.G.S. Quadrangle sheet pool elevation (Elev. 325.0) and the crest elevation of the overflow section as shown on the design plans by Lockwood, Kessler, and Bartlett, Inc. (Elev. 319.0) presumed to be NGVD.

(1) Streambed at toe of dam - 315.0

(2) Bottom of cutoff - 306.0

(3) Maximum tailwater - unknown

(4) Normal pool - 325.2

(5) Full flood control pool - N/A

(6) Spillway crest - 325.0

(7) Design surcharge (Original Design) - unknown

(8) Top of dam - 331.0

(9) Test flood design surcharge - 337.0

d. Reservoir (length in feet)

(1) Normal pool - 14,000

(2) Flood control pool - N/A

(3) Spillway crest pool - 14,000

(4) Top of dam - 26,100

(5) Test flood pool - 26,400

e. Storage (acre-feet)

(1) Normal pool - 765

(2) Flood control pool - N/A

(3) Spillway crest pool - 700

(4) Top of dam - 6,410

(5) Test flood pool - 16,370

f. Reservoir Surface (acres)

(1) Normal pool - 360

(2) Flood control pool - N/A

(3) Spillway crest - 310

(4) Test flood pool - 1855

(5) Top of dam - 1465

g. Dam

(1) Type - concrete overflow section

(2) Length - 100 feet (overflow section between training walls)

(3) Height - 15 feet (maximum)

(4) Top Width - varies

(5) Side Slopes - upstream - vertical
- downstream - ogee-shaped

(6) Zoning - unknown

(7) Impervious core - concrete

(8) Cutoff - 3 feet thick concrete curtain to Elev. 306.0

(9) Grout curtain - unknown

(10) Other - none

h. Diversion and Regulating Tunnel

Not applicable (see Section j below)

i. Spillway

(1) Type - overflow section, ogee-shaped

(2) Length of weir - 100 feet

(3) Crest elevation - 325.0 (top of overflow section)

(4) Gates - N/A

(5) U/S Channel - The banks of Little Turkey Pond and Turkey Pond are generally tree lined. The slopes of the ponds appear to be stable. No evidence of significant sedimentation was observed. The approach channel is wide and unobstructed.

(6) D/S Channel. The overflow section discharges into a natural stream channel which is approximately 30 feet wide. Below the dam, the channel is rocky and has steeply sloping banks until it passes beneath a small bridge approximately 1,000 feet downstream from the dam. Beyond the bridge, the channel discharges into an unnamed pond at the west end of the St. Pauls School campus. The upper portion of the pond is tree lined. However, as the dam which impounds this pond is approached, open, grassed banks become dominant. Various school buildings are located on the periphery of the lower portion of this pond.

j. Regulating Outlets

(1) Invert - Sluiceway - 317.0

(2) Size - Sluiceway - 36 inch diameter

(3) Description - The 36-inch diameter sluiceway pipe passes through the overflow section near the right training wall; flow is controlled by a sluice gate located on the upstream end of the sluiceway pipe.

(4) Control Mechanism - Sluice gate - self contained, non-rising stem with 4 feet long manual crank operator (removable) (crank operator removed at time of inspection)

SECTION 2
ENGINEERING DATA

2.1 Design

A set of plans dated 1957 showing plan, elevation and section for construction of the dam are available at the State of New Hampshire Water Resources Board. Another set of plans and specifications dated 1946 for the construction of St. Pauls School Dam are on file at the State of New Hampshire Water Resources Board, but this design was never implemented. The boring logs for the 1946 design were used in the 1957 - 1958 design and construction and are on file at the State of New Hampshire Water Resources Board. A copy of the specifications dated 1957 were obtained from St. Pauls School.

2.2 Construction

Construction of the dam was begun in 1957 and completed in 1958 by Manchester Sand, Gravel and Cement Company, Inc. of Bow, New Hampshire. A set of monthly construction performance records were obtained from St. Pauls School.

2.3 Operation

No engineering operational data were found.

2.4 Evaluation

a. Availability. The St. Pauls School Dam was designed by Lockwood, Kessler, and Bartlett, Inc., Consulting Engineers, Syosset, New York, and built by Manchester Sand, Gravel and Cement Company, Inc. of Bow, New Hampshire. Other than the plans, boring logs, specifications and construction performance reports, no additional engineering data were found.

b. Adequacy. Available engineering data and drawings are considered adequate for a Phase I investigation.

c. Validity. The field investigation indicated that the external features of St. Pauls School Dam substantially agree with those shown on the furnished plans dated 1957.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. St. Pauls School Dam impounds a pond area of intermediate size. The drainage area above the dam consists of moderately sloping terrain surrounding a broad swampy area adjacent to Turkey Pond. The majority of the basin is heavily wooded and numerous houses are located along the roadways which transect the drainage area. The downstream area is rocky and has steeply sloping banks that are heavily wooded.

The field inspection of St. Pauls School Dam was made on February 5, 1980. The inspection team consisted of personnel from S E A Consultants Inc. and Geotechnical Engineers, Inc. Inspection checklists, completed during the visual inspection, are included in Appendix A. At the time of inspection, water was passing approximately 2-1/2 inches deep over the 100 feet wide overflow section. The pool elevation was at approximately 325.20 NGVD. The upstream face of the dam could only be inspected above this water level.

b. Dam. St. Pauls School Dam is a concrete overflow section approximately 15 feet high from the bottom of the upstream channel to the top of the training walls and approximately 100 feet long between the training walls. (See Photo No. 2 and Plans and Details in Appendix B.) The upstream face of both training walls shows slight spalling of the concrete at the pond elevation probably due to ice formation. (See Photo No. 4.) The upstream face of the concrete overflow section is vertical and measures approximately 9 feet from its crest to a concrete apron on the channel bottom. The downstream face is ogee shaped and measures approximately 11 feet from its crest to a concrete apron on the bottom of the downstream channel. A lower section of the training walls, about 2.5 feet above tailwater elevation, extends approximately 35 feet farther downstream from the toe of the dam. (See Photo No. 6.)

No bedrock exposures were observed at either abutment of the dam. At the north (left) abutment there is no vegetation, some erosion, and evidence of trespassing on the upstream side of the fill behind the training wall. (See Photo No. 3.) There is riprap on the downstream side of the fill behind the training wall and minor erosion of the downstream slope near the crest close to the abutment. (See Photo No. 5.) Small birch trees are growing behind the training wall, both upstream and downstream of the crest of the dam. (See Photo Nos. 2 and 5.) Some water is seeping over the top of the low section of training wall along the north side of the discharge channel immediately downstream of the dam. Because the north side of the valley is rather steep and high, it is not possible to evaluate on the basis of the visual inspection alone whether this seepage is coming from the reservoir or whether it is a natural groundwater discharge from the side of the valley.

At the south (right) abutment, there is no vegetation, considerable erosion, and evidence of trespassing on the upstream side of the fill behind the training wall. (See Photo No. 6.) Small trees are growing behind the training wall both upstream and downstream of the crest of the dam. At the time of the inspection, there was an icing caused by water seeping over the top of the low section of the training wall along the south side of the discharge channel immediately downstream of the dam. (See Photo No. 6.) As with the corresponding seepage on the north side of the channel, it is not possible to determine on the basis of the visual inspection alone whether this seepage is coming from the reservoir, or whether it is a natural groundwater discharge from the high steep natural slope on the south side of the valley.

There are five (5) holes in the downstream ogee face of the dam. According to the design drawings for the dam, these holes appear to be the outlet for an 8-inch underdrain pipe beneath the dam. Water flowing over the dam at the time of the inspection made it impossible to inspect these holes at close hand, but they did appear to be open on the basis of what could be observed from the ends of the dam.

The design plans show a concrete apron which extends 20 feet upstream from the dam; a concrete cutoff wall, 3 feet wide and extending 9 feet 3 inches below the elevation of the bottom of the upstream concrete apron; and a concrete apron which extends to a point 50 feet downstream from the upstream vertical face of the dam. (See Plans and Details in Appendix B.) Because the reservoir was full and there was tailwater at the downstream toe of the dam, none of these features could be observed during the visual inspection.

c. Appurtenant Structures. Located through the overflow section near the right training wall is the sluiceway which consists of a 36-inch diameter pipe controlled by a sluice gate with a submerged gate stem operator. The gate at present is closed and is leaking slightly. (See Photo No. 7.)

d. Reservoir Area. The slopes of the reservoir appear to be stable. No evidence of significant sedimentation was observed. The approach channel to the dam is unobstructed. (See Photo No. 1.)

e. Downstream Channel. There is riprap on both banks of the discharge channel immediately downstream from the low concrete training walls at the downstream side of the dam. (See Photo No. 2.) Small trees overhang the discharge channel for a distance estimated to be about 100 feet downstream from the dam, and large trees overhang the channel farther downstream. (See Photo Nos. 8, 9 and 10.)

3.2 Evaluation

On the basis of the results of the visual inspection, St. Pauls School Dam is considered to be in fair condition.

Some soil erosion has occurred on the upstream side of both the north and south abutments and on the downstream side of the north abutment. This erosion has resulted from trespassing and lack of grassy vegetation. If it is allowed to continue, it could lead to breaching of the soil backfill at the abutments of the concrete overflow section of the dam.

Seepage discharging over the top of the low concrete training walls on the north and south sides of the discharge channel immediately downstream of the dam could develop into a long-term erosion problem if not controlled.

Small trees growing behind the training walls at both ends of the concrete overflow section of the dam are not a problem today, but could result in serious seepage and erosion problems when the trees grow larger, if a tree should then blow over and pull out its roots, or if a tree should die or be cut and its roots rot.

Ice damage to the upstream face of the concrete training walls at pond elevation, although not a problem at present, could continue and lead to serious deterioration of the training walls.

Leakage of the sluice gate which is a sign of improper seating or deterioration of the gate could lead to further deterioration.

SECTION 4
OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. The St. Pauls School Dam is used primarily to retain the waters of Little Turkey Pond and adjacent Turkey Pond to provide a rowing course for St. Pauls School.

b. Description of Any Warning System in Effect. No written warning system exists for the dam.

4.2 Maintenance Procedures

a. General. The owner, the St. Pauls School, is responsible for the maintenance of the dam. The St. Pauls School maintenance procedure is to visually inspect all structures located on the ponds and river within the confines of the school campus approximately four times a year.

b. Operating Facilities. No formal plan for maintenance of operating facilities was disclosed.

4.3 Evaluation

The current maintenance procedures for St. Pauls School Dam are inadequate to insure that all problems encountered can be remedied within a reasonable period of time. The owner should establish a written operation and maintenance procedure, as well as establish a warning system to follow in event of flood flow conditions or imminent dam failure.

SECTION 5
EVALUATION OF HYDROLOGIC/HYDRAULIC FEATURES

5.1 General. St. Pauls School Dam is a concrete overflow section approximately 15 feet high from the bottom of the upstream channel to the top of the training walls, and approximately 100 feet long between the training walls. The crest of the ogee shaped overflow section is at an elevation of 325.0 (based on a datum derived from the Concord Quadrangle U.S.G.S. topographic map). A 36-inch diameter sluice gate with an invert elevation of 317.0 is located near the right training wall. The dam impounds an interconnected pair of ponds whose connecting channel functions as a rowing course for St. Pauls School. A large flat swampy area encompasses much of the "upper" pond (Turkey Pond), and, consequently, the available storage behind the dam increases significantly as the water surface rises above the spillway crest elevation. The dam is classified as intermediate in size, having a maximum storage of approximately 6,410 acre-feet.

5.2 Design Data. No hydrological or hydraulic design data were disclosed.

5.3 Experience Data. No experience data were disclosed. Maximum flood flows or elevations are unknown.

5.4 Test Flood Analysis. Due to the absence of detailed design and operational information, the hydrologic evaluation was performed utilizing data gathered during field inspection, watershed size and an estimated test flood equal to the Probable Maximum Flood (PMF) as determined with the "rolling" curve from the Corps of Engineers set of guide curves.

Based on a maximum probable flood peak flow rate of 1,325 cfs per square mile and a drainage area of 29 square miles, the test flood inflow was estimated to be 38,400 cfs. The test flood was routed through the reservoir in accordance with the Corps of Engineers procedure for Estimating Effect of Surcharge Storage on Maximum Probable Discharge. The reservoir water surface was assumed to be at elevation 325.0 prior to the flood routing. The routed test flood outflow was estimated to be 17,200 cfs. This analysis indicated that the dam crest would be overtopped by 6.0 feet. The maximum spillway capacity with the water level at the dam crest was estimated to be 5,660 cfs, which is only about 33 percent of the test flood discharge.

5.5 Dam Failure Analysis. The impact of dam failure with the reservoir surface at the dam crest was assessed utilizing the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs published by the Corps of Engineers. The analysis covered a reach extending approximately 0.8 miles downstream to the dam impounding the pond at the St. Pauls School campus. Based on this analysis, the dam has been classified as a significant hazard structure.

Since the dam's spillway extends almost the entire length of the dam, the discharge over the spillway with the water surface at the dam crest (top of training walls) is quite significant when compared to the dam failure discharge. Consequenty, the tailwater resulting from this spillway discharge raises the stage in the downstream reaches nearly as much as the dam failure discharge. In a situation such as this, the hazard potential should be assessed by failing the dam with the water surface at the crest of the spillway.

If failure occurs with the water surface at the spillway crest, the major point of impact would be near the dam impounding the downstream ponding area. The water surface in the pond would be raised nearly 4 feet. This would cause water to enter one of the classroom buildings near the dam to a depth of 1 to 2 feet above the sill, causing damage to the lower floor of this building. Water would also flow over the two roadways crossing this pond (less than 1 foot deep), possibly causing damage to the roadways and bridges. In addition to this, the dam creating this impoundment could be damaged by the discharge over the abutments. It is not anticipated that lives would be lost.

SECTION 6
EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

The visual inspection indicates the following potential structural problems:

(1) Some soil erosion has occured on the upstream side of both the north and south abutments and on the downstream side of the north abutment. This erosion has resulted from trespassing and lack of grassy vegetation. If it is allowed to continue, it could lead to breaching of the soil backfill at the abutments of the dam.

(2) Seepage discharging over the top of the low training walls on the north and south sides of the discharge channel immediately downstream of the dam could develop into a long-term erosion problem if not controlled.

(3) Small trees growing behind the training walls at both ends of the concrete overflow section of the dam are not a problem today, but could result in serious seepage and erosion problems when the trees grow larger, if a tree should then blow over and pull out its roots, or if a tree should die or be cut and its roots rot.

(4) Ice damage to the upstream face of the concrete training walls at pond elevation, although not a problem at present, could continue and lead to serious deterioration of the training walls.

(5) Leakage of the sluice gate which is a sign of improper seating or deterioration of the gate could lead to further deterioration.

Because the reservoir was filled at the time of the inspection, it was not possible to examine the condition of the concrete apron which extends upstream from the concrete gravity section of the dam.

Because water was flowing over the dam at the time of the inspection, it was not possible to examine at close-hand, the condition of the drain holes near the bottom of the downstream face of the dam.

Because tailwater was standing at the downstream toe of the dam, it was not possible to examine the concrete apron which extends downstream from the dam.

6.2 Design and Construction Data

The dam was designed by Lockwood, Kessler, and Bartlett, Inc., Consulting Engineers, Syosset, New York, in 1957. Construction began that same year by Manchester Sand, Gravel and Cement Company, Inc., Bow, New Hampshire and was completed in 1958. These design plans indicate that sections of the concrete dam are reinforced and built on an earth foundation.

The plans show four features which are important but which could not be examined: (1) upstream apron; (2) downstream apron; (3) gravel underdrain with 8-inch pipe beneath the dam, discharging through five drain holes near the bottom of the downstream face of the dam; and (4) concrete cutoff wall, 3 feet wide and extending to a depth of 9 feet, 3 inches below the bottom of the upstream concrete apron.

The drawings do not show any cutoff provisions below the bottom of the concrete cutoff wall mentioned above. The plans do show cutoff walls in the abutments beyond the training walls at each end of the overflow section, although it is impossible to determine from the plans the depth of the walls, reinforcement, or thickness below grade.

The logs of borings taken in the general vicinity of the dam indicate that the foundation soils consist of dense sand, gravel, and boulders, and locally, some clay. Bedrock was encountered in three borings, at elevations about 75 to 90 feet below the crest of the dam.

6.3 Post-Construction Changes

There is no record of changes since the construction of the dam.

6.4 Seismic Stability

This dam is located in Seismic Zone 2 and, in accordance with the Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination indicates that St. Pauls School Dam is in fair condition. The main concerns with respect to the integrity of the dam are:

(1) Erosion and lack of erosion protection on the soil abutments.

(2) Seepage discharging over the top of the low concrete training walls on the north and south sides of the discharge channel immediately downstream of the dam.

(3) Small trees growing on the soil abutments (not a problem today, but will become a problem if the trees are allowed to grow).

(4) Ice damage to the upstream face of the concrete training walls.

(5) Leakage of the sluice gate.

(6) Inadequacy of spillway to pass the test flood.

b. Adequacy of Information. Because water was flowing over the concrete section of the dam at the time of the inspection, it was not possible to inspect at close hand the downstream face of the dam or the drain holes through which the underdrain discharges. These features should be inspected at a time when no water is flowing over the dam.

The information available from the visual inspection and hydrologic and hydraulic analyses is adequate to identify the problems listed in 7.2. These problems will require the attention of a qualified registered professional engineer who will have to make additional engineering studies to design or specify remedial measures. No additional information is needed for the purpose of this Phase I inspection.

c. Urgency. The owner should implement the recommendations in 7.2 and 7.3 within one year after receipt of this Phase I report.

7.2 Recommendations

The owner should retain a registered professional engineer qualified in the design and construction of dams to:

(1) Specify erosion protection for the soil abutments of the dam.

(2) Investigate the seepage discharging over the top of the low concrete training walls near the downstream toe of the dam and design remedial measures if needed.

(3) Inspect the downstream face of the dam and the drain holes through which the underdrain discharges, at a time when no water is flowing over the dam.

(4) Investigate the leakage of the sluice gate.

(5) Do a detailed hydrologic-hydraulic investigation to assess further the potential of overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity.

The owner should carry out the recommendations made by the engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The owner should:

(1) Cut the trees from a zone 25 feet wide on each side of the dam and downstream channel from a point 25 feet upstream of the crest to a point 50 feet downstream of the crest.

(2) Repair the spalling of concrete at pool elevation on the upstream face of the concrete training walls.

(3) Control trespassing on the abutments.

(4) Establish a regular operation and maintenance program.

(5) Engage a registered professional engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once every year.

(6) Establish a surveillance program for use during and after heavy rainfall, and also a warning program to follow in case of emergency conditions.

7.4 Alternatives

There are no practical alternatives to the recommendations of Section 7.2 and 7.3.

APPENDIX A

INSPECTION CHECK LIST

INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT: St. Paul's School Dam, NH

DATE: February 5, 1980

TIME: 0900

WEATHER: Clear, cold

W.S. ELEV. 325.2 U.S. 316.5 DN.S.
(U.S.G.S. Datum)

PARTY:

1. Kenneth Stewart, S E A
2. Robert Durfee, S E A
3. Philip Ricardi, S E A
4. Ronald Hirschfeld, GEI
5. Richard DeBold, NHWRB
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Structural stability	K. Stewart/R. Durfee	
2.	Hydrology / hydraulics	B. Pierstorff/P. Ricardi	
3.	Soils and geology	R. Hirschfeld	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH   DATE: February 5, 1980

PROJECT FEATURE: Dam Embankment   NAME: ______

DISCIPLINE: ______   NAME: ______

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	325.0
Current Pool Elevation	325.2
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Not paved
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alighment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	Foot paths at both abutments
Vegetation on Slopes	Both abutments bare of vegetation
Sloughing or Erosion of Slopes or Abutments	Significant erosion on right abutment
Rock Slope Protection - Riprap Failures	None observed
Unusual Movement or Cracking at or near Toe	None observed
Unusual Embankment or Downstream Seepage	Groundwater seepage over top of both lower training walls
Piping or Boils	None observed
Foundation Drainage Features	Not visible
Toe Drains	None observed
Instrumentation System	None

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH DATE: February 5, 1980

PROJECT FEATURE: Dike Embankment NAME: ______

DISCIPLINE: ______ NAME: ______

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT	No dike
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Vegetation on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or near Toes	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH   DATE: February 5, 1980

PROJECT FEATURE: Intake Channel   NAME: ______

DISCIPLINE: ______   NAME: ______

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	
Slope Conditions	Good
Bottom Conditions	Not visible beneath ice on pond
Rock Slides or Falls	None
Log Boom	None
Debris	None
Condition of Concrete Lining	Not applicable
Drains or Weep Holes	None
b. Intake Structure	
Condition of Concrete	Not visible
Stop Logs and Slots	None

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH DATE: February 5, 1980

PROJECT FEATURE: Control Tower NAME: ______

DISCIPLINE: ______ NAME: ______

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	No control tower. Sluice gate operated from top of right training wall with 4 foot long removable crank.
a. Concrete and Structural	
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	Not applicable
Float Wells	Not applicable
Crane Hoist	Not applicable
Elevator	Not applicable
Hydraulic System	Not applicable
Service Gates	Sluice gate - not visible beneath pond surface
Emergency Gates	Same as service gates
Lightning Protection System	Not applicable
Emergency Power System	Not applicable
Wiring and Lighting System	Not applicable

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH

DATE: February 5, 1980

PROJECT FEATURE: Transition and Conduit

NAME:

DISCIPLINE:

NAME:

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	36-inch diameter reinforced concrete pipe through overflow section. Not visible due to water over dam.
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH DATE: February 5, 1980

PROJECT FEATURE: Outlet Structure NAME: ______

DISCIPLINE: ______ NAME: ______

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Good
Rust or Staining	None visible
Spalling	None visible
Erosion or Cavitation	None visible
Visible Reinforcing	None
Any Seepage or Efflorescence	Minor leakage from gate
Condition at Joints	Not visible
Drain holes	None
Channel	
Loose Rock or Trees Overhanging Channel	Small trees overhang channel near dam; large trees overhang channel farther downstream
Condition of Discharge Channel	Good

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH

DATE: February 5, 1980

PROJECT FEATURE: Spillway Weir

NAME:

DISCIPLINE:

NAME:

AREA EVALUATED	CONDITIONS
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	Not visible beneath ice on pond
b. Weir and Training Walls	
General Condition of Concrete	Good
Rust or Staining	None visible
Spalling	Spalling at ponding level due to ice damage
Any Visible Reinforcing	None
Any Seepage or Efflorescence	None visible
Drain Holes	Five drains across downstream face of weir
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Small trees overhang channel close to dam; large trees overhang channel farther downstream
Floor of Channel	Concrete apron & stone paving (not visible)
Other Obstructions	None

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH DATE: February 5, 1980

PROJECT FEATURE: Service Bridge NAME: ____________

DISCIPLINE: ____________ NAME: ____________

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SERVICE BRIDGE	No service bridge
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

INSPECTION CHECK LIST

PROJECT: St. Paul's School Dam, NH

DATE: February 5, 1980

PROJECT FEATURE: Service Bridge

NAME:

DISCIPLINE:

NAME:

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SERVICE BRIDGE	No service bridge
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

ENGINEERING DATA

AVAILABLE ENGINEERING DATA

A set of plans dated 1957 showing plan, elevation, and section for construction of the St. Pauls School Dam and boring logs are available at the State of New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301. A copy of the specifications dated 1957 and construction performance reports were obtained from St. Pauls School, Pleasant Street, Concord, New Hampshire 03301.

PAST INSPECTION REPORTS

M E M (

Date: February 5, 1980

To: Vernon A. Knowlton,
Chief Engineer

From: Richard W. DeBold, RWD
Water Resources Engineer

Subject: Corps Inspection of Turkey Pond Dam, No. 51.25, Concord

On February 5, 1980 I accompanied the inspection team from SEA Consultants to the subject dam. This was a follow-up visit by this consultant to an initial site inspection done on December 5, 1979, at that time accompanied by Ken Stern of this Office.

The reason for the second visit was per the request of the Corps of Engineers for a full inspection report.

Initially SEA had submitted a letter report only, after classifying Turkey Pond Dam as a low hazard dam. There is some question whether the downstream reach and pond would attenuate a breaching without causing severe damage to property and endangering lives of the residence of St. Paul's School.

The dam on this date is in good condition and only a couple of items of maintenance were observed.

1- Small trees are growing on both embankments next to th abutments.

2- Portions of the right abutment are erodible bare earth.

I believe any action can wait until receipt of the report.

RWD:paf

M E M O

Date: December 5, 1979

Filed for CE Report
OK/VAK

To: Vernon A. Knowlton,
Chief Engineer

From: Ken Stern,
Water Resources Engineer KS

Subject: Corps Inspection of Turkey Pond Dam, No. 51.25, Concord

On December 4, 1979 I accompanied the inspection team from SEA Consultants. The dam is in good condition. The consultants are of the opinion that this is a low hazard dam.

Certain items of maintenance were observed:

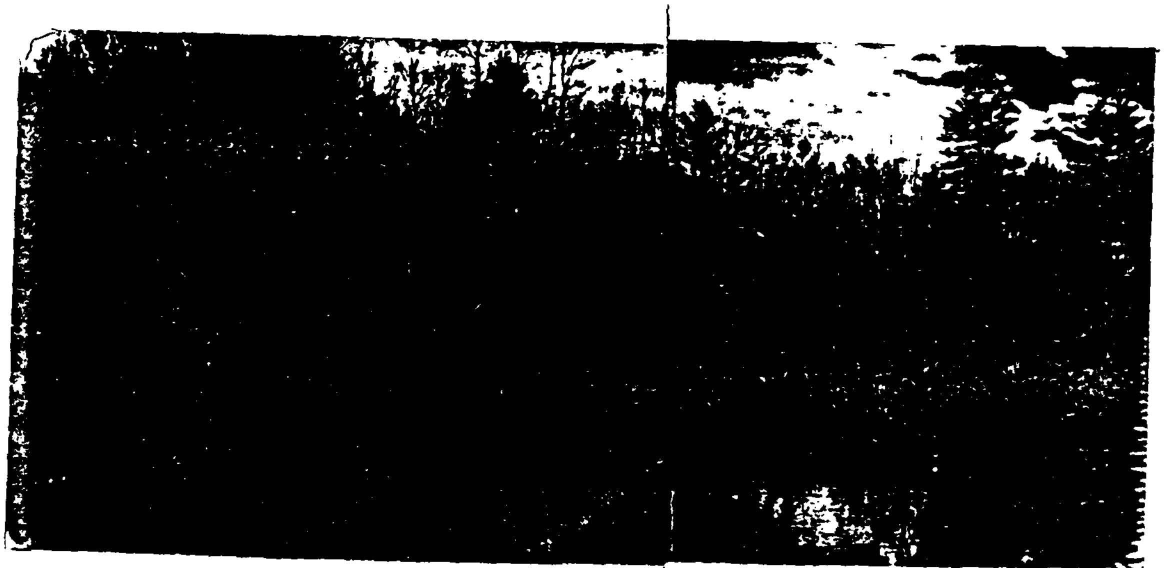
1- Small trees are growing on both embankments next to the abutments.

2- Portions of the right abutment are erodible bare earth.

There is slight seepage downstream of both abutments.

I believe any action can wait until receipt of the report.

KS:paf



51.25

State of New Hampshire

WATER RESOURCES BOARD
37 Pleasant Street
Concord, N.H. 03301

TELEPHONE 271-3406

July 10, 1978

Mr. John Beust, Vice Rector
Buildings and Grounds
St. Paul's School
Concord, New Hampshire 03301

Dear Mr. Beust:

Under the provisions of RSA Chapter 482, Sections 8 through 15, the New Hampshire Water Resources Board is authorized to inspect all dams in the State which by reason of their physical condition, height and location may be a menace to public safety.

On June 28, 1978 an engineer from this Office inspected the three dams on the grounds of St. Paul's School. As a result of this inspection certain discrepancies were found which should require corrective measures in order to protect the integrity of the structure.

Dam No. 51.12 on the Lower School Pond by Hargate- This dam has been classified as in fair condition due to the condition of the gates and gate mechanism. We have a memorandum in our files dated June 2, 1975 that Paul Talbot could not operate the gates at that time and that there were plans to replace the gates and guides. It appears that this work has not been done. The items in need of attention for this structure are as follows:

1- If the gates are still inoperable this situation should be remedied.

2- There is leakage around the left gate, apparently through a section of deteriorated concrete, that should be fixed.

3- The concrete around the gate opening is in a severely deteriorated condition and should be repaired.

(Item No. 2 and No. 3 can be observed from the downstream side of the gates under the wooden platform.)

4- There are several small trees growing directly out of or very close to the downstream, right side, stone retaining walls. These trees should be cut to prevent possible root damage to the structure. Some of the trees in the area are far enough back from the wall that they are not a problem.

July 10, 1978

Mr. John Beust, Vice Rector
Buildings and Grounds
St. Paul's School

Dam No. 51.25 Turkey Pond Dam- This dam has been classified as a menace structure in good condition. No spalling or cracks in the concrete were observed. There is some minor leakage through the pond drain which is of little consequence at the present but should be periodically checked.

Should you make the suggested repairs in the waters of the State, you may need a permit from the Special Board. Applications can be obtained by writing or calling the Special Board Office, 37 Pleasant Street, Concord, New Hampshire 03301, telephone no. 271-2147.

Please feel free to call or write if you have any questions regarding the evaluation of your structures.

Sincerely,

George McGee Sr.

GMM:KS:paf

George N. McGee, Sr.,
Chairman

NEW HAMPSHIRE WATER RESOURCES BOARD

INSPECTION REPORT

Town: CONCORD Dam Number: 51.25

Name of Dam, Stream and/or Water Body: TURKEY POND DAM

Owner: ST PAUL'S SCHOOL Telephone Number: 225-3341

Mailing Address: CONCORD NH

Max. Height of Dam: 8'± Pond Area: 400 ACRES ± Length of Dam: 100'±

FOUNDATION: EARTH

OUTLET WORKS: CONCRETE GRAVITY SPILLWAY
42" GATE VALVE

ABUTMENTS: CONCRETE

EMBANKMENT: EARTH BARE IN SPOTS

Note: Give Sizing, Condition and detailed description for each item, if applicable.

Dam No. 51.25

SPILLWAY: Length: 100' ± Freeboard: 4'

SEEPAGE: Location, estimated quantity, etc.

GATE VALVE LEAKS
SOME WATER COMING OUT OF WEEP HOLE
IN SPILLWAY
DOWNSTREAM RET. WALLS DAMP BUT
NO DISCERNABLE SEEPAGE

Changes Since Construction or Last Inspection:

NONE

Tail Water Conditions:

FREE FLOWING

Overall Condition of Dam: GOOD

Contact With Owner: YES

Date of Inspection: 6/28/78 Suggested Reinspection Date ______

Class of Dam: MENACE?

Signature Kenneth Ster

Date 6/28/78

Note: Give Sizing, Condition and detailed description for each item, if applicable.

Dam No. 41.25

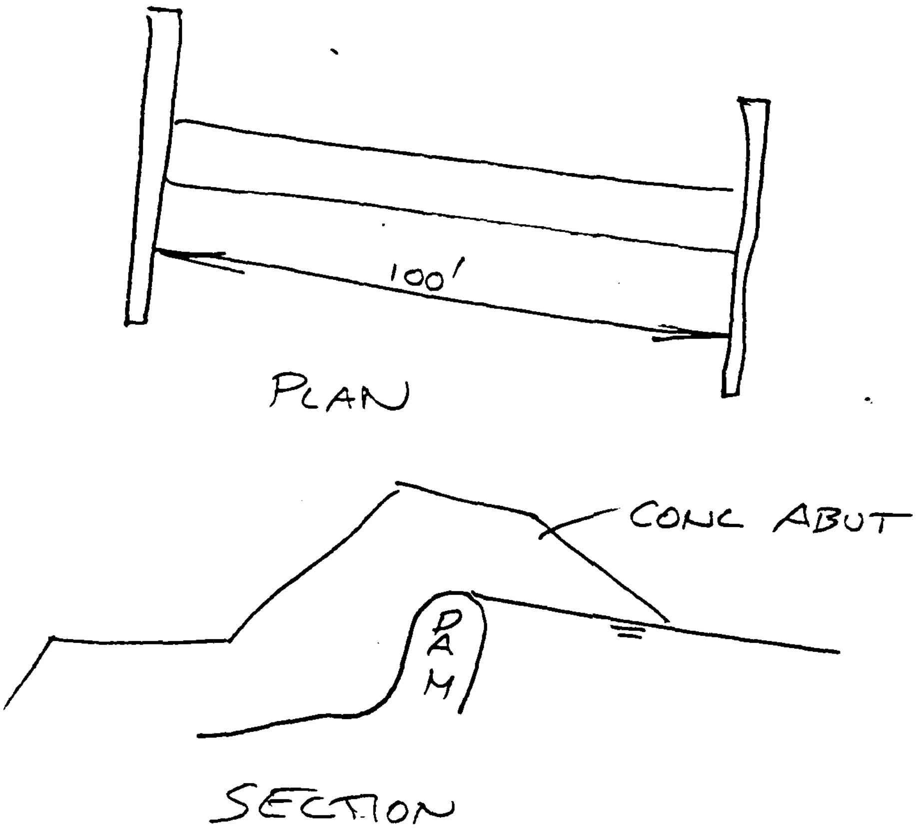
COMMENTS:

① GATE VALUE LEAKS
② SEEPAGE THROUGH WEEP HOLE IN SPILLWAY @ TOE

VIEW OF SPILLWAY FROM RT. EMBANKMENT

Dam No. 51,25

SKETCH OF DAM (Show Plan, Elevation & Cross Sections)



NEW HAMPSHIRE WATER RESOURCES BOARD

INSPECTION REPORT

Town: [illegible] Dam Number: 51.25

Name of Dam, Stream and/or Water Body:

Owner: St. Paul's School Telephone Number:

Mailing Address:

Max. Height of Dam: [illegible] Pond Area: Length of Dam: [illegible]

FOUNDATION: Earth

OUTLET WORKS:

ABUTMENTS: 18" thick Concrete Seems to be in good condition

EMBANKMENT:

Note: Give Sizing, Condition and detailed description for each item, if applicable.

Dam No. 5125

SPILLWAY: Length: Freeboard: 6'

SEEPAGE: Location, estimated quantity, etc.

Changes Since Construction or Last Inspection:

Tail Water Conditions:

Overall Condition of Dam:

Contact With Owner: None

Date of Inspection: 12 5 '77 Suggested Reinspection Date Spring '78

Class of Dam:

Signature

Date 12-5-77

Note: Give Sizing, Condition and detailed description for each item, if applicable.

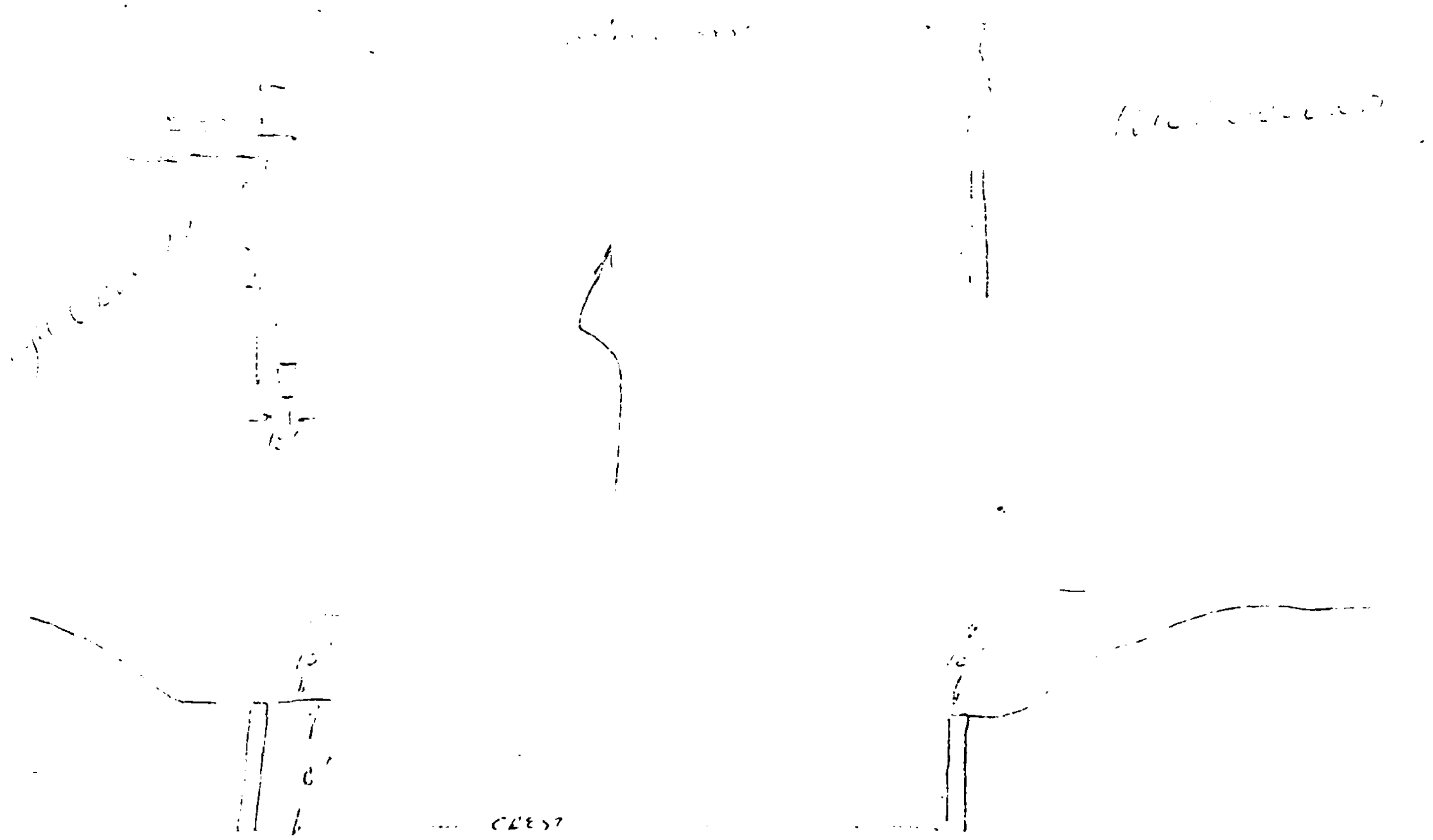
Dam No. 51.25

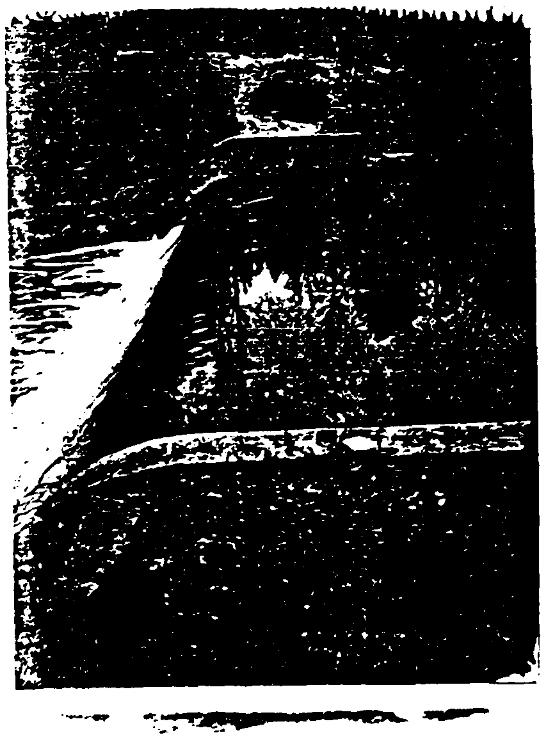
COMMENTS:

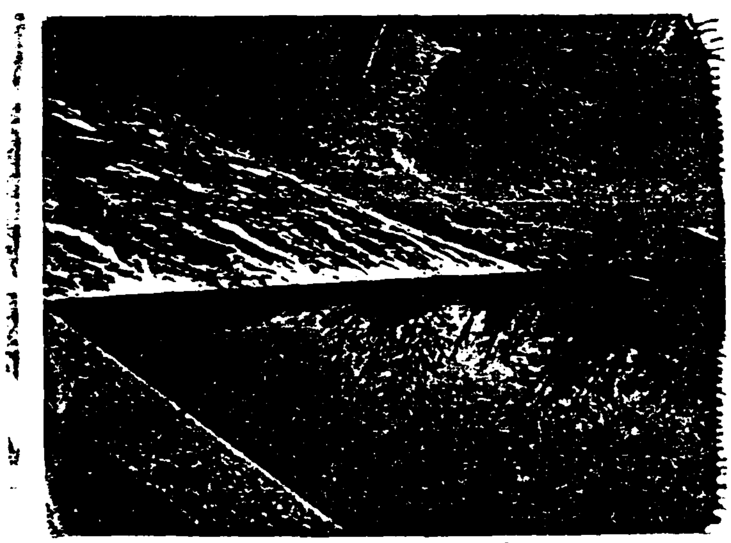
Too much water to adequately inspect. Should reinspect in Spring or summer. No signs of any distress.

Dam No.________________

SKETCH OF DAM (Show Plan, Elevation & Cross Sections)







BORING LOGS

[illegible] BORING REPORT
[illegible] [illegible] Co.
SOIL DIVISION
NEW YORK BOSTON

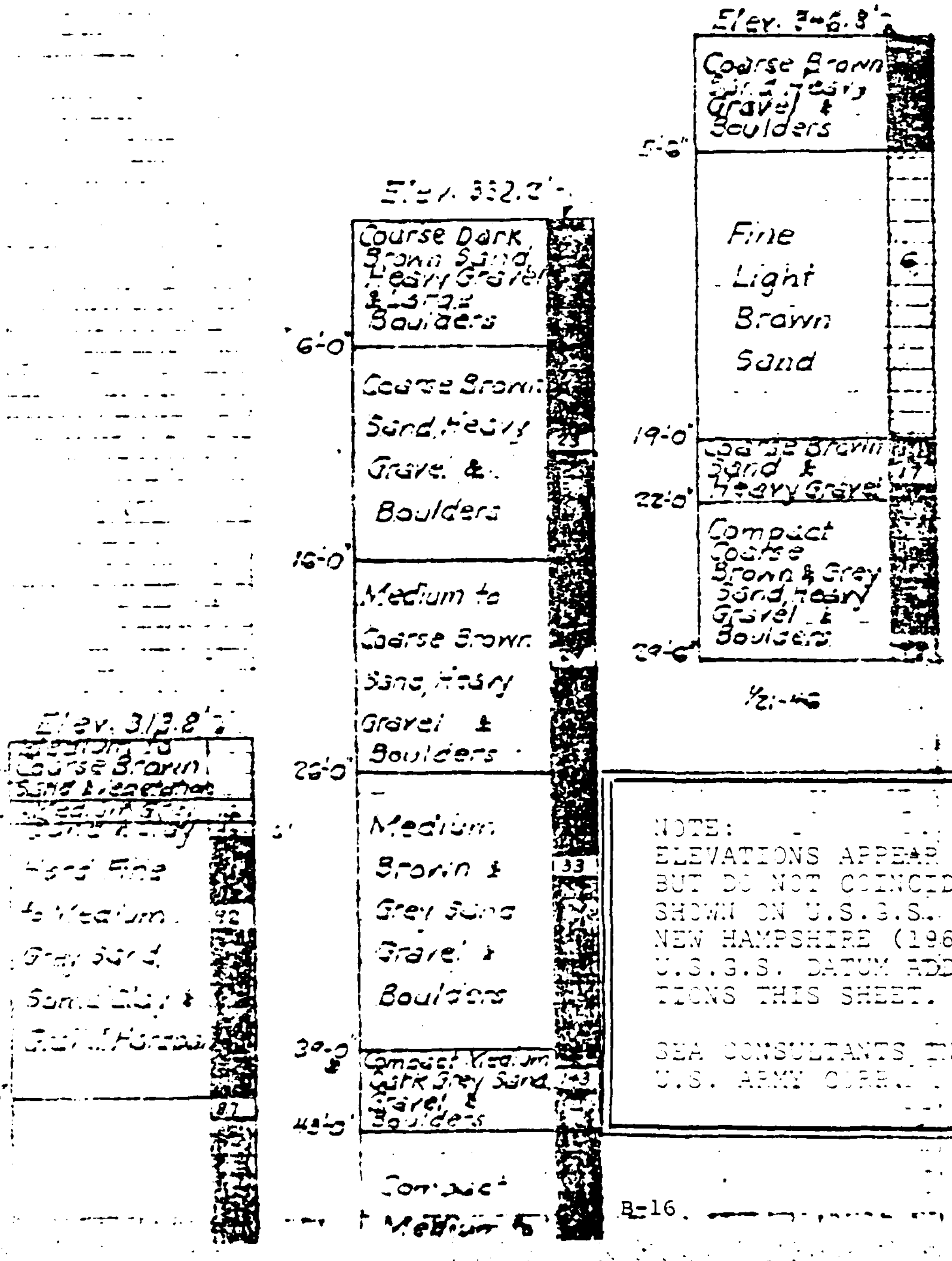
To Metcalf [illegible] Eddy Date Feb. [illegible] 194[illegible] Job No. [illegible]

Location of Borings: [illegible] Dam on Turkey River, Concord, New Hampshire.

All borings are plotted to a scale of 1" = 8 ft. using ______ as a fixed datum.

No. 6 No. 8 No. 10 No. ______

BORINGS 7 & 9 OMITTED



NOTE:
ELEVATIONS APPEAR TO REFER TO MSL DATUM BUT DO NOT COINCIDE WITH POOL ELEVATION SHOWN ON U.S.G.S. QUAD SHEET, CONCORD, NEW HAMPSHIRE (1967). TO CONVERT TO U.S.G.S. DATUM ADD 6.00 TO ALL ELEVATIONS THIS SHEET.

SEA CONSULTANTS INC.
U.S. ARMY CORPS [illegible] MARCH 1980

Sand

Gravel &

Boulders

NOTE:
ELEVATIONS APPEAR TO REFER TO MSL DATUM BUT DO NOT COINCIDE WITH POOL ELEVATION SHOWN ON U.S.G.S. QUAD SHEET, CONCORD, NEW HAMPSHIRE (1967). TO CONVERT TO U.S.G.S. DATUM ADD 6.00 TO ALL ELEVATIONS THIS SHEET.

SEA CONSULTANTS INC.
U.S. ARMY CORP. MARCH 1980

Boring shown above made one foot north of original location which was abandoned at 18 feet due to broken casing. Drilled 6" boulder at 6 feet and 8" boulder at 18 feet.

Figures in right hand column indicate number of blows required to drive sampling pipe ("A" Rod) one foot (unless otherwise noted), using 340-lb. weight falling 30 inches.

Total footage: 175

Sheet 3 of 3

BORING REPORT

Raymond Concrete Pile Co.

NEW YORK GOW DIVISION BOSTON

Date Feb. 4th, 1946 Job No. B-2813

Location of Borings Proposed Dam on Turkey River, Concord, New Hampshire.

All borings are plotted to a scale of 1" = 8 ft. using ______ as a fixed datum.

No. 1 No. 3 No. 4 No. 5

NOTE:
ELEVATIONS APPEAR TO REFER TO MSL DATUM BUT DO NOT COINCIDE WITH POOL ELEVATION SHOWN ON U.S.G.S. QUAD SHEET, CONCORD, NEW HAMPSHIRE (1967). TO CONVERT TO U.S.G.S. DATUM ADD 6.00 TO ALL ELEVATIONS THIS SHEET.

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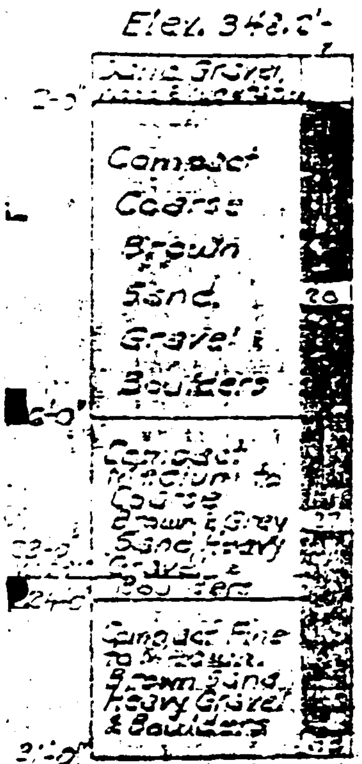
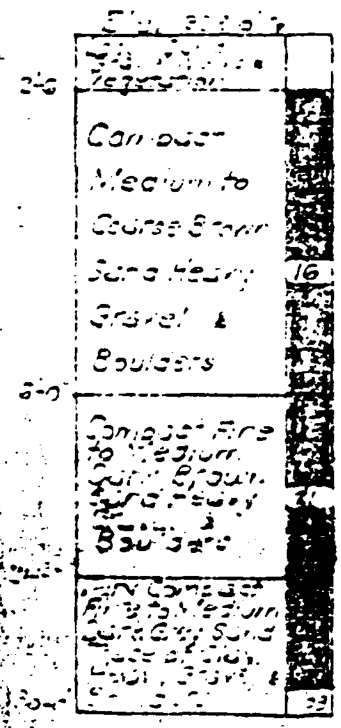
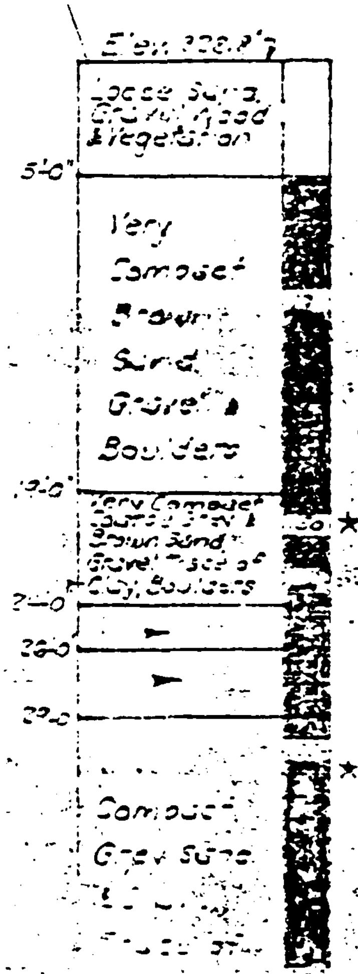


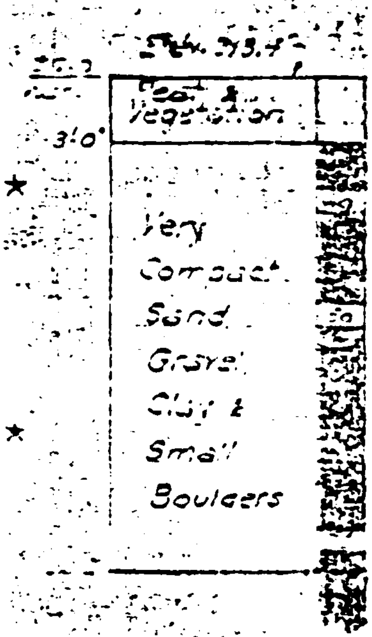
BORING #2
DELETED





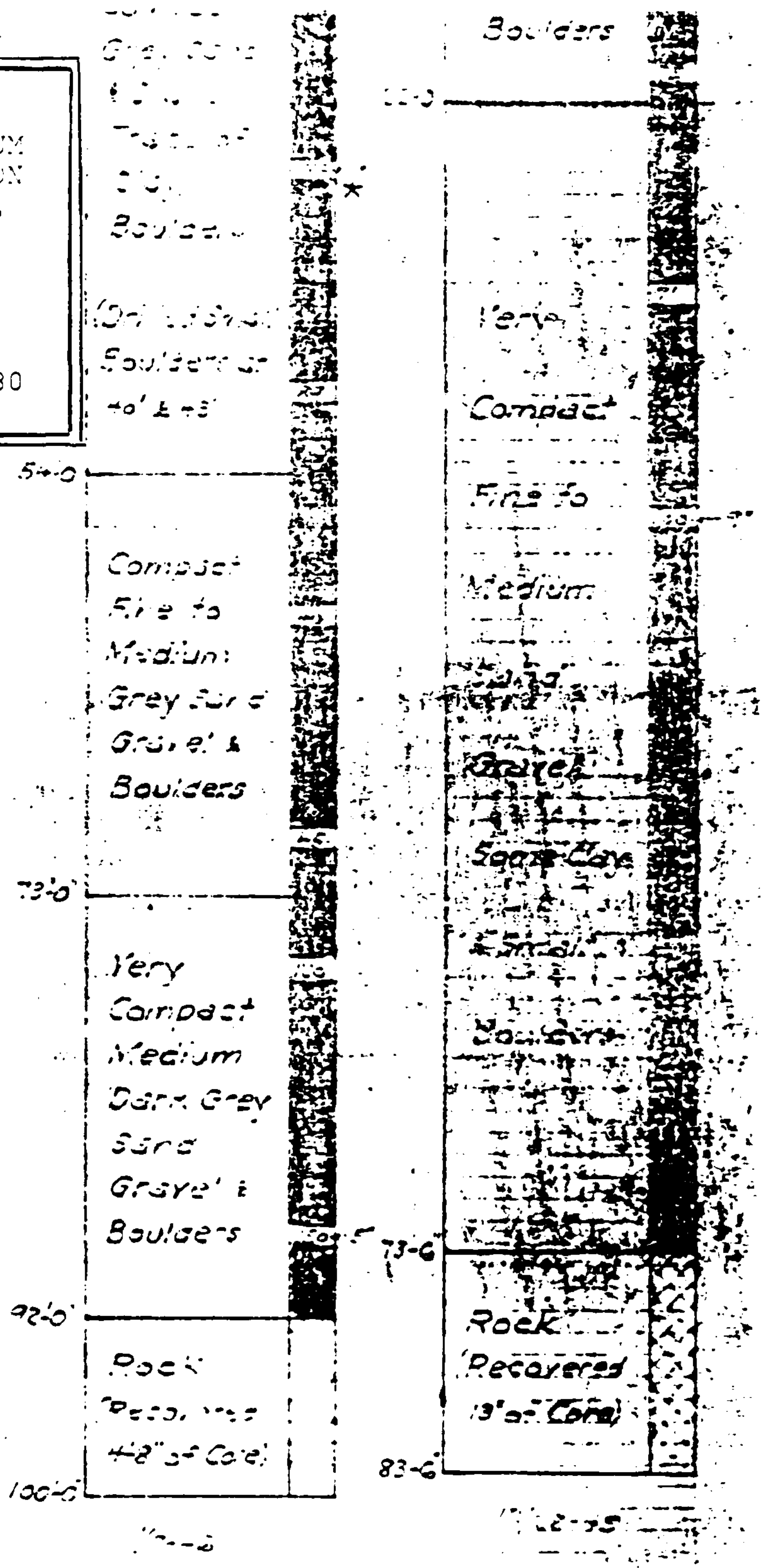
NOTE FOR BORING NO. 5

Drove 53 feet of 2-1/2" casing. Foreman reported water continuously overflowing top of casing, indicating underground springs or other source of water.



NOTE:
ELEVATIONS APPEAR TO REFER TO MSL DATUM BUT DO NOT COINCIDE WITH POOL ELEVATION SHOWN ON U.S.G.S. QUAD SHEET, CONCORD, NEW HAMPSHIRE (1967). TO CONVERT TO U.S.G.S. DATUM ADD 6.00 TO ALL ELEVATIONS THIS SHEET.

SEA CONSULTANTS INC.
U.S. ARMY CORPS MARCH 1980



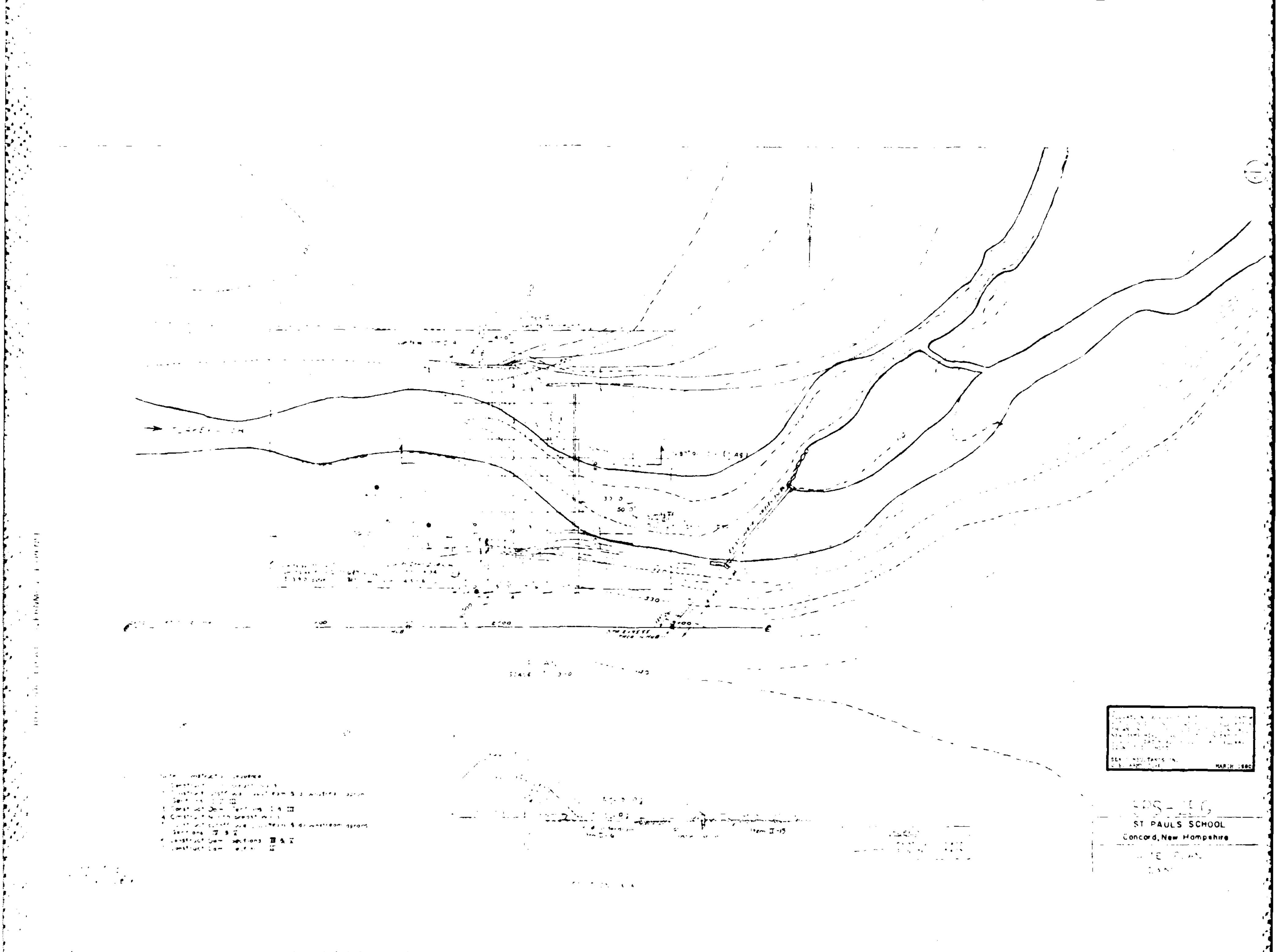
* Indicates resistance encountered when driving through boulders.

Figures in right hand column indicate number of blows required to drive sampling pipe ("A" Rod) one foot (unless otherwise noted), using 340-lb. weight falling 30 inches.

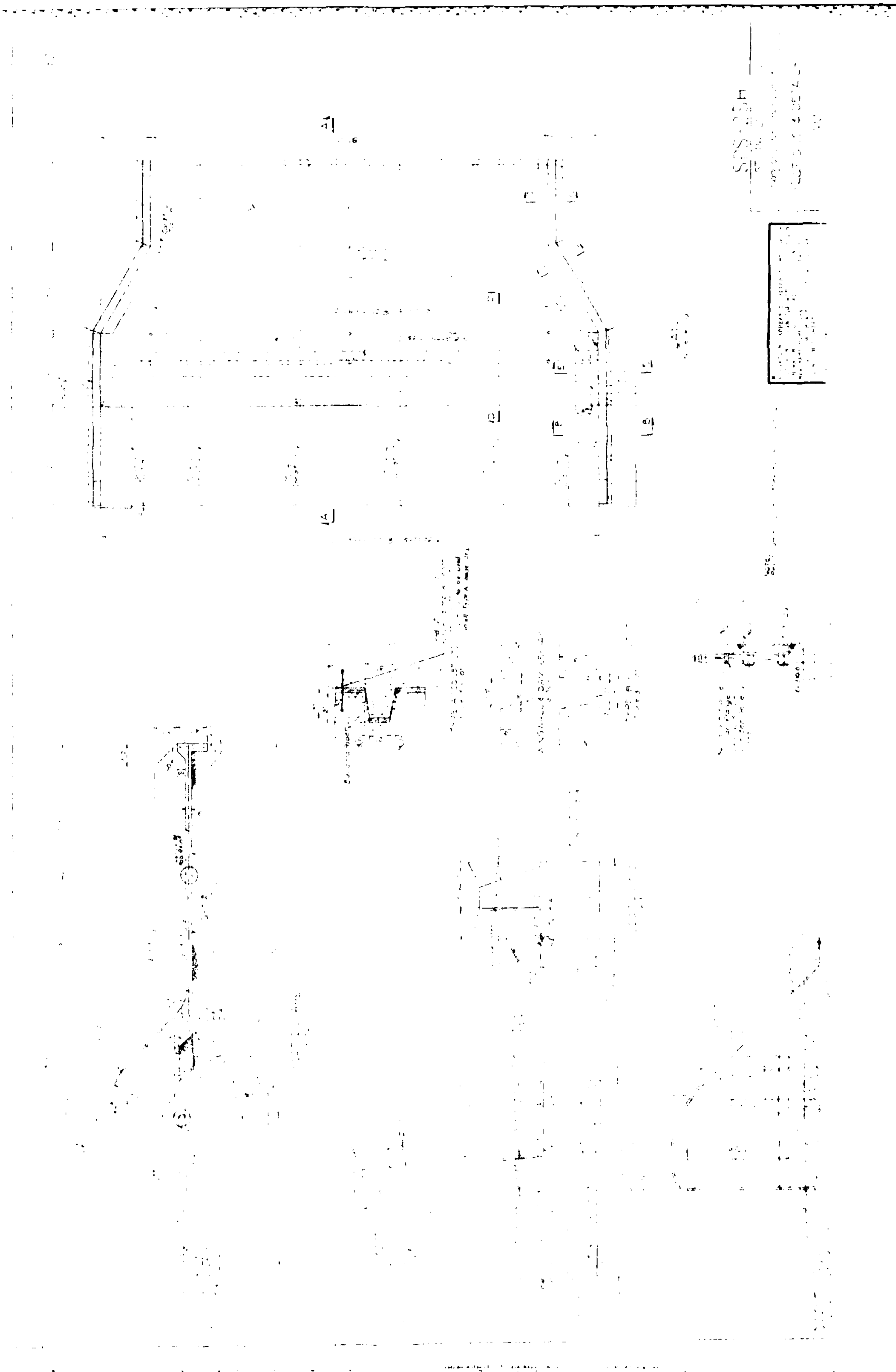
Total Footage: 244-3"
Foreman: F.C. Shippey
Sheet 2 of 3

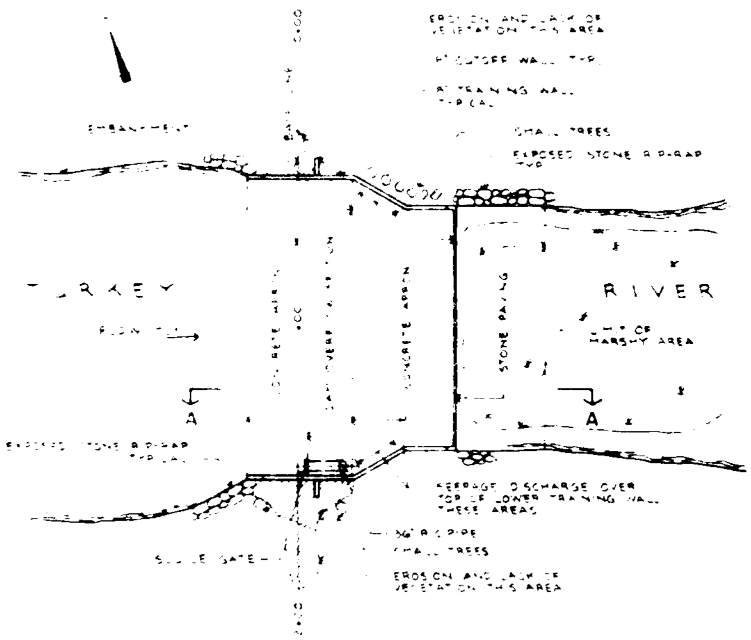
PLANS AND DETAILS

ST PAULS SCHOOL
Concord, New Hampshire

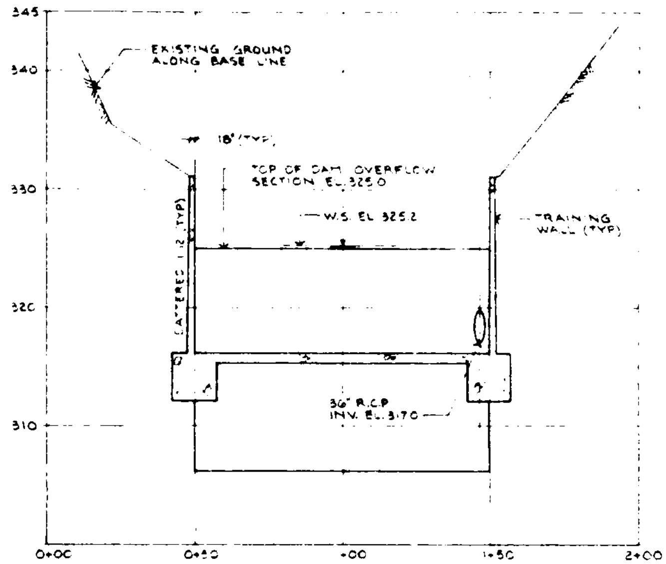


330
50.0'
2700
3+00
MARCH 1980
ST PAULS SCHOOL
Concord, New Hampshire



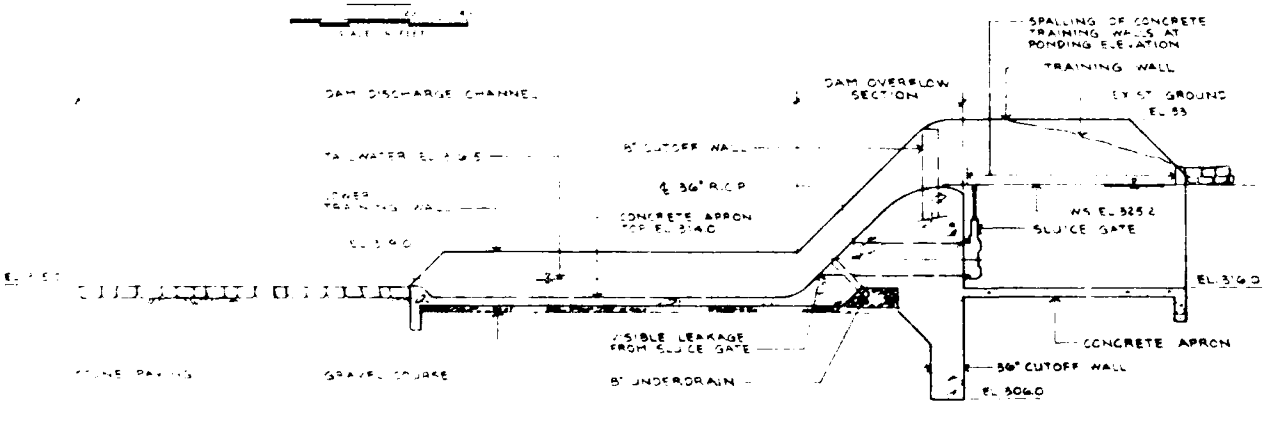


PLAN



PROFILE

(LOOKING DOWNSTREAM)



SECTION A-A

NOTES:

1) THE ELEVATIONS SHOWN ARE BASED ON AN ELEVATION OF 325 SHOWN ON U.S.G.S. QUADRANGLE SHEET ASSUMED TO BE POOL ELEVATION AT TOP OF OVERFLOW SECTION.

2) THE INFORMATION SHOWN ON THIS DRAWING IS BASED ON THE EXISTING PLANS AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DIMENSIONS OR MATERIALS INDICATED ON THIS DRAWING WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.

NATIONAL PROGRAM OF INSPECTION OF NON FED. DAMS

ST. PAULS SCHOOL DAM

APPENDIX C

SELECTED PHOTOGRAPHS

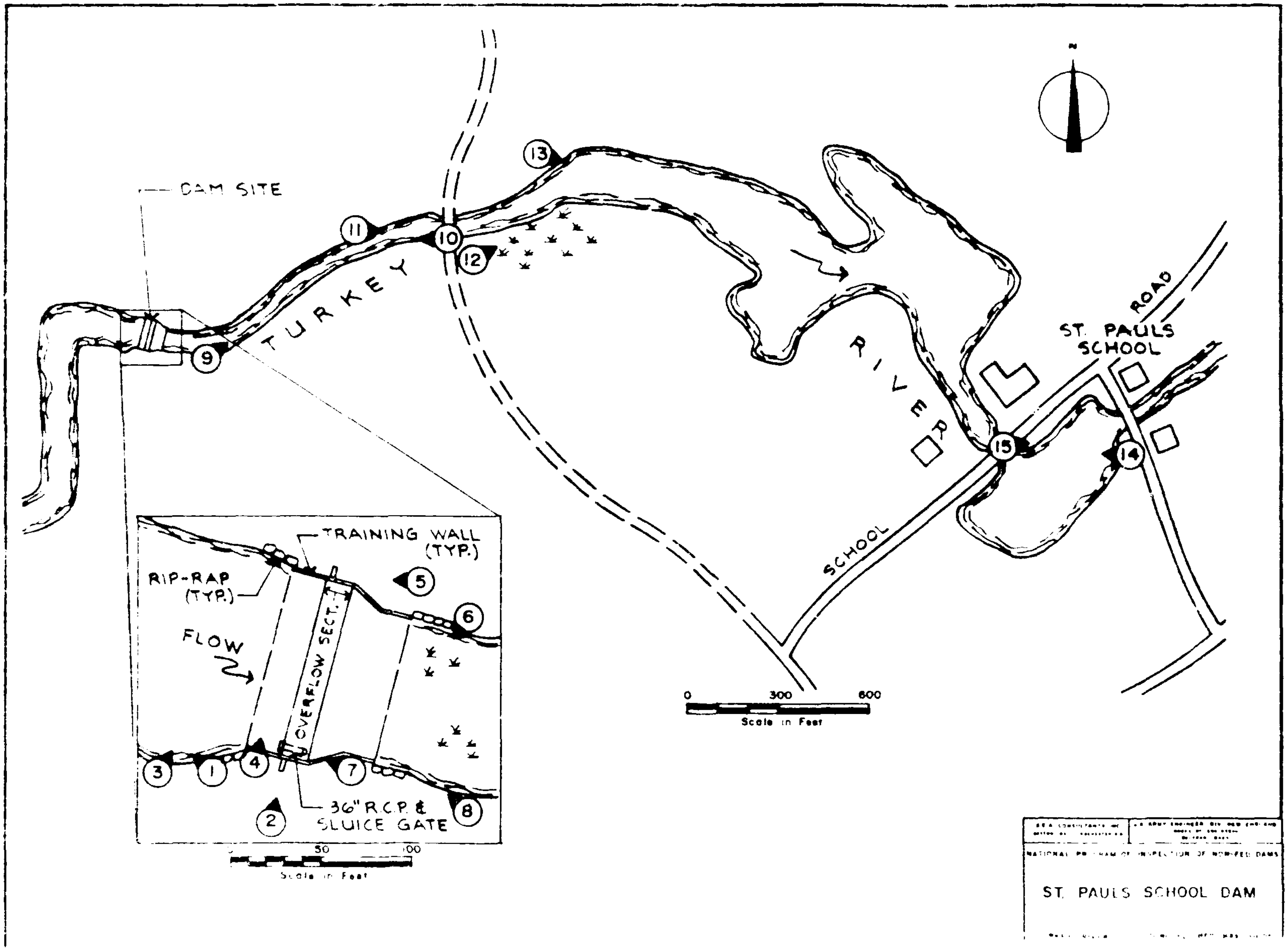

DAM SITE
TURKEY
RIVER
SCHOOL
ROAD
ST. PAULS SCHOOL
N
0 300 600
Scale in Feet
TRAINING WALL (TYP.)
RIP-RAP (TYP.)
FLOW
OVERFLOW SECT.
36" R.C.P. & SLUICE GATE
0 50 100
Scale in Feet
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS
ST. PAULS SCHOOL DAM

Photo No. 1 - General view of pond from dam.

Photo No. 2 - View of left abutment and crest of dam from right abutment.

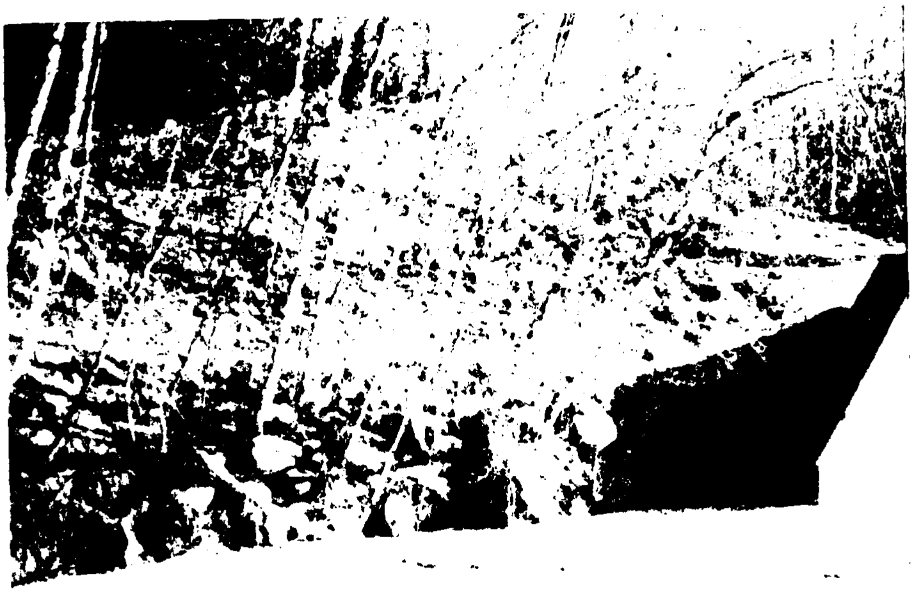


Photo No. 3 - View of riprap on upstream bank of left abutment.

Photo No. 4 - Closeup view of spalling of concrete on left training wall.

Photo No. 5 - View of downstream face
of left abutment.

Photo No. 6 - View of right abutment from downstream channel.

Photo No. 7 - Closeup view of sluiceway discharge at right training wall.

Photo No. 8 - View of downstream face of dam.

Photo No. 9 - View of downstream channel approximately 100 feet below dam.

Photo No. 10 - View looking upstream from bridge approximately 1,200 feet below dam.

Photo No. 11 - View of upstream face of bridge.

Photo No. 12 - View of marshy ponding area immediately below bridge.

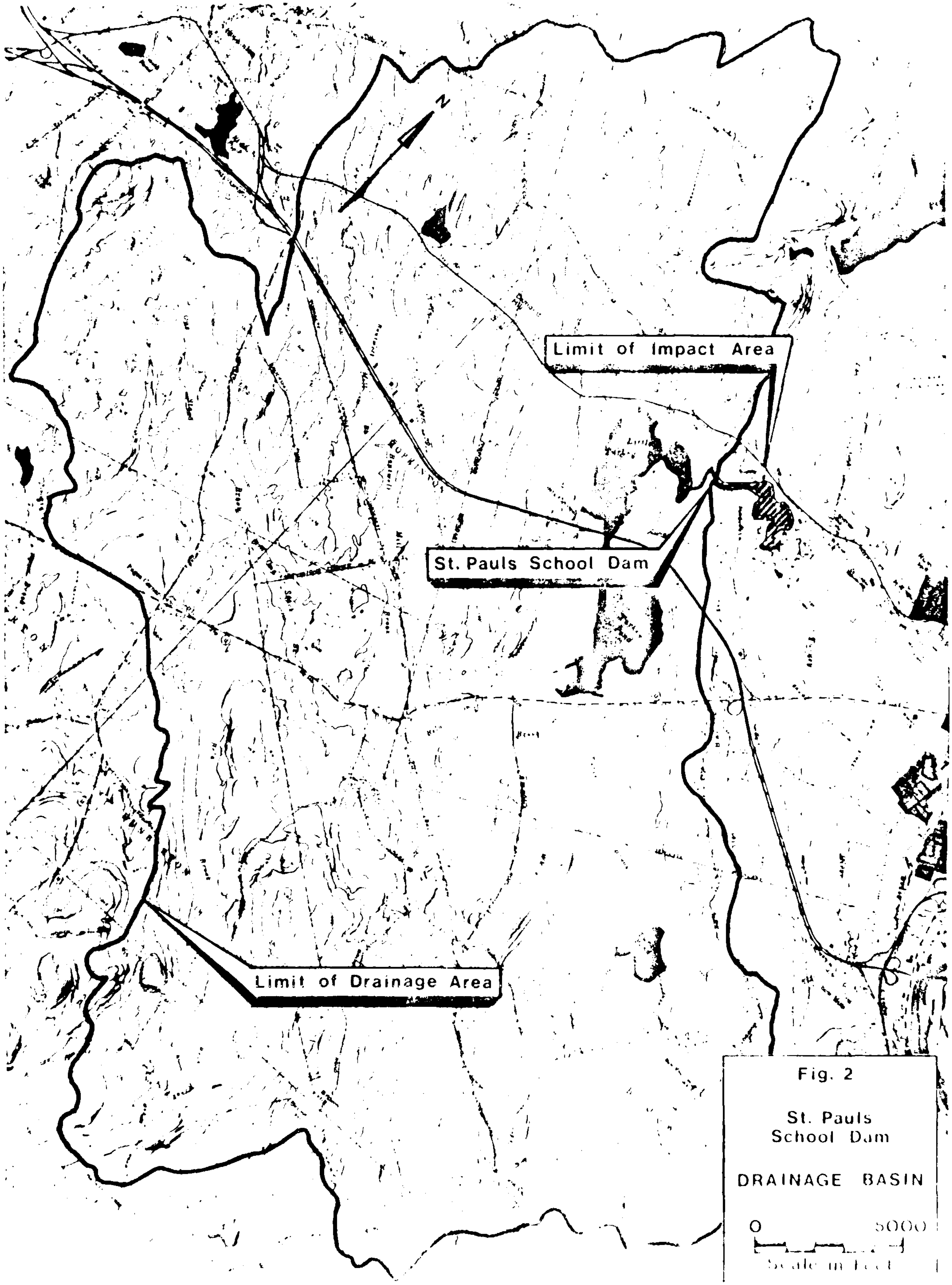
Photo No. 13 - General view of lower ponding area with St. Paul's School in background.

Photo No. 14 - View of Saint Paul's school buildings adjacent to lower ponding area.

Photo No. 15 - View of Saint Paul's School Buildings adjacent to lower ponding area.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS


N
Limit of Impact Area
St. Pauls School Dam
Limit of Drainage Area
Fig. 2
St. Pauls School Dam
DRAINAGE BASIN
0
5000
Scale in Feet

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ENGINEERS / PLANNERS

BOSTON, MASS.
ROCHESTER, N.H.

CLIENT	Army Corps	JOB NO.	274-792	PAGE	[illegible]
PROJECT	St Pauls School Dam	COMPTD. BY	[illegible]	DATE	3.20.80
DETAIL	Hydrologic Calculations	CK'D. BY	HMS	DATE	[illegible]

I. Basic Data

A. Drainage Area

1. 29 square miles - as defined on U.S.G.S sheet and then planimetered

2. Drainage area would classify as rolling for estimating MPF Peak Flow Rates

B. Dam and Storage Information

1. Size Classification: INTERMEDIATE - based on storage (≥ 1,000 ac-ft and < 50,000 ac-ft)

as indicated below storage at crest of dam (top of training walls) estimated to be 6410 acre-ft

2. Hazard Potential: SIGNIFICANT -

damage to at least one school building the dam impounding the downstream pond and one or roadway bridges crossing the pond

3 Storage Information

Descriptive Information	Elevation * (Feet)	Surface Area (Acres)	Storage (Ac-Ft)
350' contour	350.0	2700	
Dam Crest (Top of training walls)	331.0	1465	6410
330' Contour	330.0	1400	4975
[illegible] pool	325.2	[illegible]	
Spillway weir crest	325.0	310	720

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CLIENT	Army Corps	JOB NO.	224-[illegible]	PAGE	[illegible] of 34
PROJECT	St Paul's School Dam	COMPTD. BY	[illegible]	DATE	[illegible]
DETAIL	[illegible]	CK'D. BY	JMS	DATE	[illegible]

* Notes: (1) elevations: NGVD – based on 335 pond surface shown on [illegible]

(2) Pool shown on U.S.G.S. sheet [illegible] assumed to correspond with elevation of spillway weir crest - 325.0 feet

(3) Pond surface area at dam crest determined by interpolating between surface area [illegible] by 330' and 350' contours

(4) Storage at spillway weir crest estimated by dividing reservoir into pyramidal frustrum sections and determining the volume of each section with the equation for the volume of a pyramidal frustrum

C. Spillway Information

1. [illegible] spillway consists of an ogee-crested weir which nearly spans the entire width of the [illegible] channel [illegible] training wall is a 3' diameter sluicegate which is normally closed.

a. For subsequent calculation of spillway capacity [illegible] the surcharge storage analysis it is assumed that the sluicegate is closed

2. Discharge over spillway given by [illegible] crested weir equation

$$Q = CLH^{3/2}$$ (standard [illegible] [illegible])

where Q = discharge, cfs
L = weir length, feet
H = head over crest, feet
C = discharge coeff. – [illegible] by Fig 21-67 [illegible]

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CLIENT [illegible] Corps	JOB NO. 274-770	PAGE	[illegible] of 84
PROJECT St Pauls School Dam	COMPTD. BY RWP	DATE	2/20/80
DETAIL [illegible]	CK'D. BY KMS	DATE	[illegible]

II. Estimate Effect of Surcharge Storage on [illegible] Discharge

A. Develop stage-discharge curve for out-flow from dam

1. define sources of out flow

a. discharge over ogee-crested spillway - [illegible] elevation 325.0 - as defined above

b. discharge over training walls and "abutments" above elevation 331.0 use broad-crested weir equation with C = 2.6

(1) Since the maximum probable [illegible] of inflow into the ponding area is very large the discharge from the dam will also need to be very large in order to satisfy the requirements of the 1st iteration in the [illegible]. To obtain an adequate discharge from the dam site flows up to about 20 [illegible] the spillway crest will need to be examined. See "the side slopes" [illegible] the cross-section (perpendicular to the direction of flow) through the abutments will [illegible] broken into sections [illegible].

2. Discharge over spillway

Elevation feet, NGVD	C	L feet	H feet	Q cfs
325.0	—	—	0	0
326.0	3.4	100	1	340
327.0	3.6	[illegible]	2	[illegible]
328.0	3.65		3	[illegible]900
329.0	3.75		4	3 000
331.0	3.85		6	5 [illegible]
335.0	3.9		10	12 300
340.0	3.95		15	22 [illegible]
345.0	3.95		20	[illegible]
346.0	3.95	↓	21	[illegible]

3. Discharge over training walls

Elevation feet NGVD	C	L feet	H feet	Q cfs
331.0	—	—	0	0
335.0	2.6	3	4	62
340.0	2.6	3	9	≈ 210
345.0	2.6	3	14	≈ 410
346.0	2.6	3	15	≈ 450

4 Discharge over right "abutment"

a First section

Elevation feet NGVD	C	L feet	avg. H feet	Q cfs
331.0	—		0	0
335.0	2.6	14	2	103
340.0	2.6	29	4.5	720
345.0	2.6	41	7.6	2,230
346.0	2.6	41	8.6	2,690

b. Second section

Elevation feet NGVD	C	L feet	avg. H feet	Q cfs
343.8	—	—		0
345.0	2.6	29	0.6	35
346.0	2.6	49	1.2	≈ 170

5. Discharge over left "abutment"

a. First section

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CLIENT [illegible]　　JOB NO. 274-7901　　PAGE [illegible] 34
PROJECT St. Paul [illegible] Dam　　COMPTD. BY BWP　　DATE 2/20/[illegible]
DETAIL [illegible]　　CK'D. BY [illegible]　　DATE [illegible]

Elevation feet NGVD	C	L, feet	avg H feet	Q cfs
331.0	—		0	0
335.0	2.6	23	2	170
340.0	2.6	26	6.8	1,200
345.0	2.6	26	11.8	2740
346.0	2.6	26	12.8	3,100

b Second Section

Elevation feet NGVD	C	L feet	avg. H [illegible]	Q cfs
335.4	—	—	0	0
340.0	2.6	8	2.3	[illegible] 70
345.0	2.6	11	6.5	[illegible] 475
346.0	2.6	11	7.5	1,590

c Third Section

Elevation feet NGVD	C	[illegible]	[illegible]	Q [illegible]
341.6	—		0	0
345.0	2.6	300	1.7	[illegible]
346.0	2.6	455	2.2	3,450

6 TOTAL DISCHARGE — [illegible] F. 1

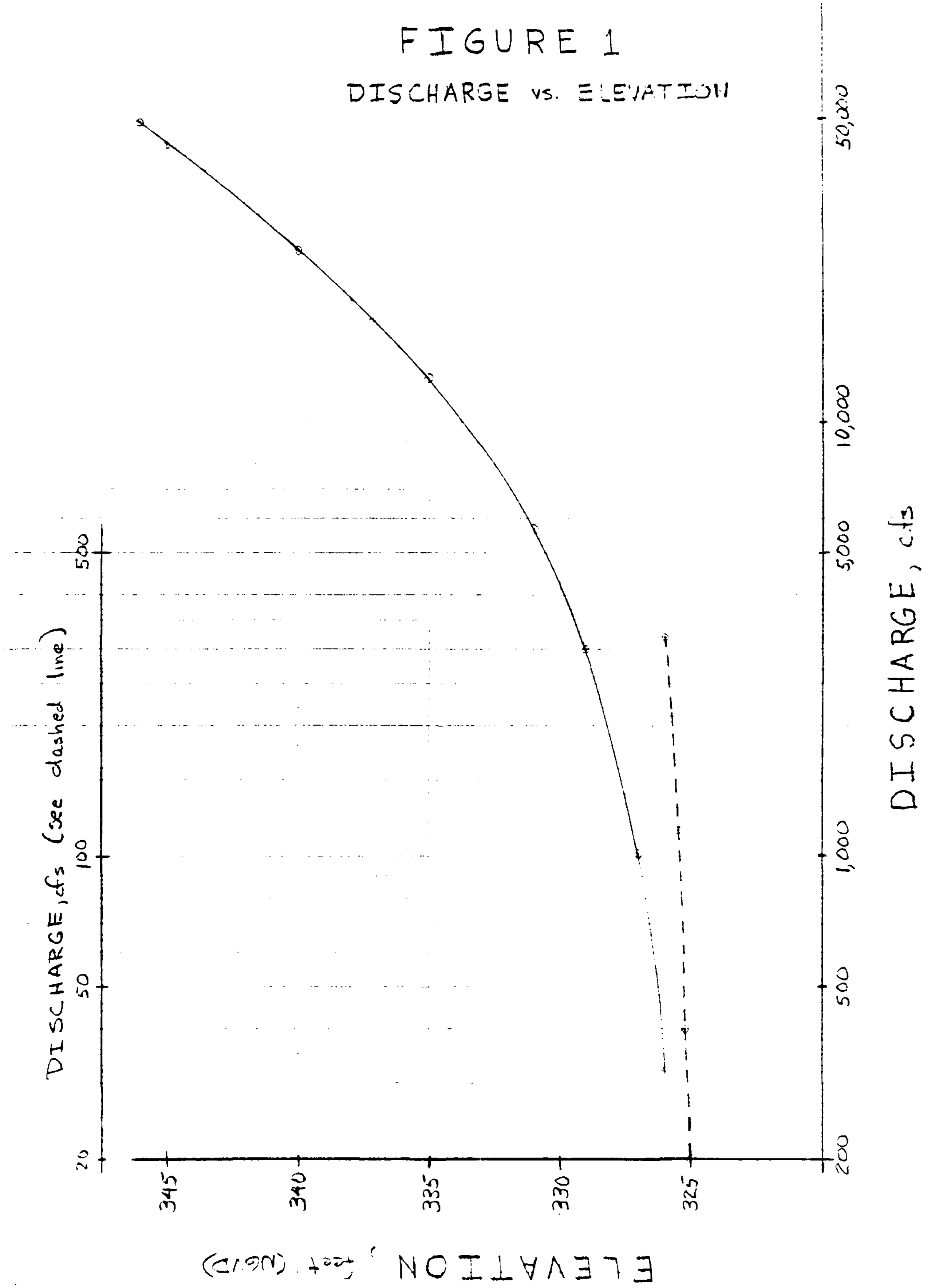
Elevation feet NGVD	Spillway Q	[illegible] Q	Total [illegible] Q	Total [illegible] Q	TOTAL Q
325.0	0	0	0	0	0
326.0	340	0	0	0	[illegible]
327.0	1,020	0	0	0	[illegible]
328.0	[illegible]	0	0	0	[illegible]
329.0	3,000	0	0	0	[illegible]
331.0	5,660	0	0	0	[illegible]
335.0	12,300	67	103	170	12,500
340.0	22,900	210	720	1,270	24,900
345.0	35,800	4[illegible]	2265	[illegible]	43,300
346.0	38,000	[illegible]	2,860	7,640	48,900

St Pauls School Dam Job # [illegible]

2/21/80 GMS

FIGURE 1

DISCHARGE vs. ELEVATION



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CLIENT Army Corps
PROJECT St Pauls School Dam
DETAIL Hydrologic Calcs
JOB NO. [illegible]
COMPTD. BY [illegible]
CK'D. BY KMS
PAGE 7 of [illegible]
DATE [illegible]
DATE [illegible]

B. Effect of surcharge storage on max. prob. discharge

1. Pertinent Data

a. Drainage area = 29 square miles
b. Characteristics of basin - rolling
c. Test flood = PMF
d. Follow Army Corps' procedure

2. STEP 1: Determine Peak Inflow Q_{P1} from Guide Curve

a. the maximum probable discharge was estimated to be 1325 cfs/sq.mi

∴ PMF = (1325 cfs/sq mi)(29 sq mi)

≈ 38,400 cfs

3. STEP 2: Determine surcharge height to pass Q_{P1}, $STOR_1$, and Q_{P2}

a. from Figure 1 determine surcharge height to pass Q_{P1} = 38,400 cfs

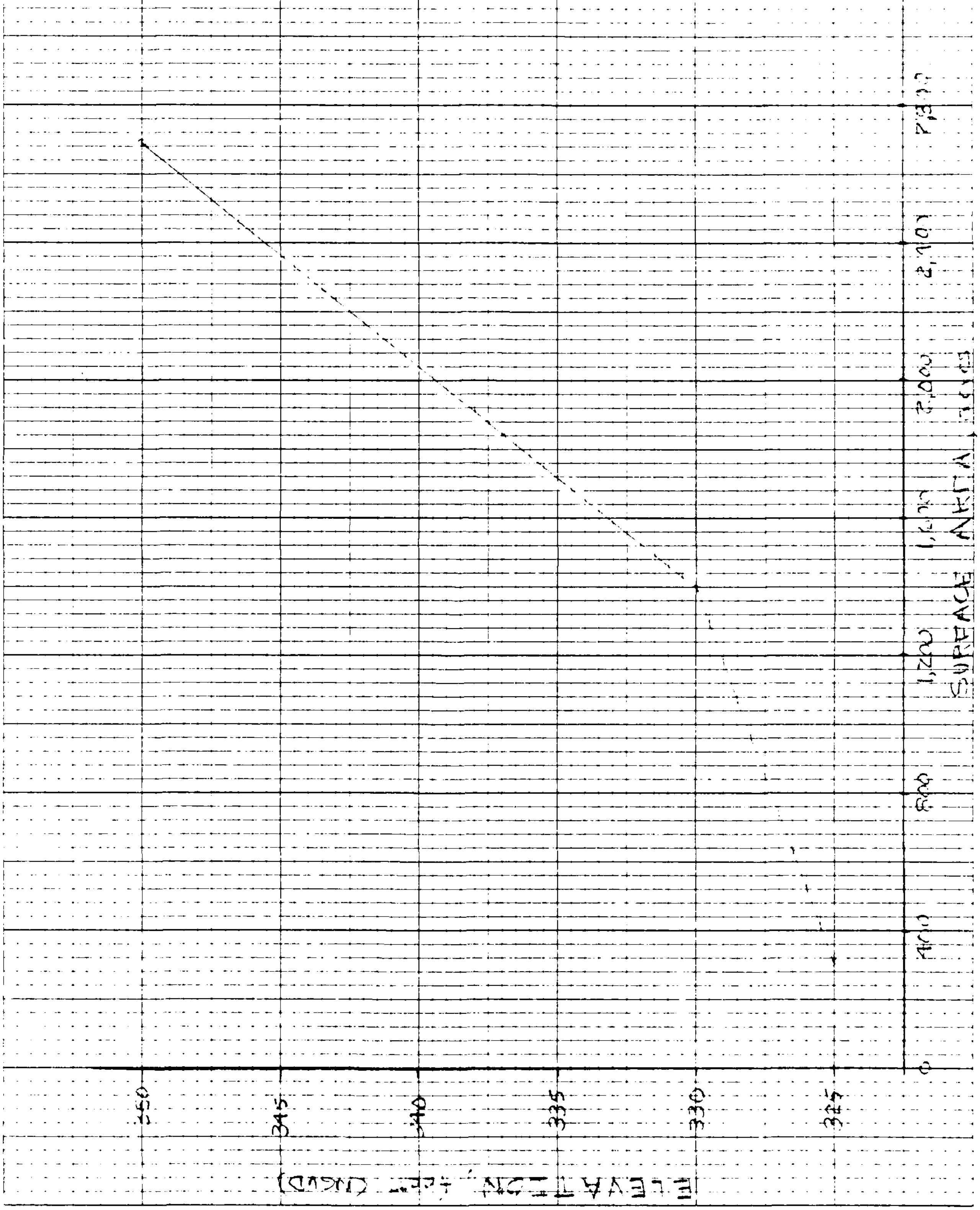
surcharge elevation = [illegible]'
spillway weir crest elev. = 325.0'
surcharge height = 13.5

b. determine volume of surcharge $STOR_1$ in inches of runoff
first determine volume of storage in acre-ft in [illegible] manner:
(1) determine surface area of pond corresponding to surcharge elevation from Figure 2 = 2260 acres
(2) determine average surface area for surcharge [illegible]
(a) [illegible] line in this [illegible] since surface area vs elevation line [illegible] not have a constant slope
① between elevations 325 and 330
② above elevation 330'

Dam Doc # 274-7901

FIGURE 2

SURFACE AREA vs. ELEVATION



(3) multiplying each portion of the surcharge height by the corresponding average surface area to determine the volume of storage in acre-ft for input into the following equation

$$STOR_1 = \frac{\text{Volume of storage (as acre-inches)}}{\text{drainage area}}$$

$$STOR_1 = \frac{\left[(5\,ft)\left(\frac{310\,acres + 1400\,acres}{2}\right) + (13.5\,ft)\left(\frac{1400\,acres + 2200\,acres}{2}\right)\right](12''/ft)}{(29\,sq.\,miles)(640\,acres/sq.\,mi)}$$

$$STOR_1 = 18.73\text{ inches}$$

c. determine Q_{P2}

$$Q_{P2} = Q_{P1}\left(1 - \frac{STOR_1}{19''}\right)$$

$$Q_{P2} = (38{,}400\,cfs)\left(1 - \frac{18.73''}{19''}\right)$$

$$Q_{P2} = 546\ cfs$$

4. STEP 3: Determine surcharge height and STOR$_2$ to pass Q_{P2} and then Q_{P3}

a. From Figure 1 determine surcharge height to pass Q_{P2} = 546 cfs

surcharge elevation = 326.5'
spillway weir crest elev = 325.0
surcharge height = 1.5 feet

Surface area @ 326.5' = 640 acres

b. determine $STOR_2$

$$STOR_2 = \frac{(1.5\,ft)\left(\frac{310\,acres + 640\,ac}{2}\right)(12''/ft)}{(29\,sq\,mi)(640\,acres/sq\,mi)}$$

$= 0.46$ inches

c. Average $STOR_1$ and $STOR_2$

$$STOR_{AVG} = \frac{STOR_1 + STOR_2}{2}$$

$$STOR_{AVG} = \frac{18.73\,in + 0.46\,in}{2}$$

$STOR_{AVG} = 9.60$ inches

d. determine Q_{P3}

$$Q_{P3} = (38{,}400\,cfs)\left(1 - \frac{9.60''}{19''}\right)$$

$Q_{P3} = 19{,}000$ cfs

5. STEP 4: Determine surcharge height for Q_{P3} and $STOR_3$

a. from Figure 1 surcharge height for $Q_{P3} = 19{,}000$ cfs

Surcharge elevation = 338.0'
spillway weir crest elev. = 325.0'
surcharge height = 13.0 feet

surface area at 338.0' = 1920 acres

b. determine $STOR_3$

$$STOR_3 = \frac{\left[(5\,ft)\left(\frac{310\,ac + 1400\,ac}{2}\right) + (8.0\,ft)\left(\frac{1400\,ac + 1920\,ac}{2}\right)\right](12''/ft)}{(29\,sq\,mi)(640\,acre/sq\,mi)}$$

$$STOR_3 = 11.35 \text{ inches}$$

c. determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{9.60 \text{ inches} + 11.35 \text{ inches}}{2}$$

$$STOR_{AVG} = 10.48 \text{ inches}$$

d. determine Q_{P4}

$$Q_{P4} = (38{,}400 \text{ cfs})\left(1 - \frac{10.48''}{19''}\right)$$

$$Q_{P4} = 17{,}200 \text{ cfs}$$

6. STEP 5: Determine surcharge height for Q_{P4} and $STOR_4$

a. From Figure 1 surcharge height for Q_{P4} = 17,200 cfs

$$\begin{aligned} \text{surcharge elevation} &= 337.0' \\ \text{spillway weir crest elev} &= 325.0' \\ \text{surcharge height} &= 12.0 \text{ feet} \end{aligned}$$

surface area at 337.0 = 1840 acres

b. determine $STOR_4$

$$STOR_4 = \frac{\left[(5 \text{ ft})\left(\frac{310 \text{ ac} + 1400 \text{ ac}}{2}\right) + (7.0 \text{ ft})\left(\frac{1400 \text{ ac} + 1840 \text{ ac}}{2}\right)\right](12''/\text{ft})}{(29 \text{ sq. mi})(640 \text{ acres/sq. mi})}$$

$$STOR_4 = 10.10 \text{ inches}$$

c. determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{10.48 \text{ inches} + 10.10 \text{ inches}}{2}$$

$$= 10.29 \text{ inches}$$

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ENGINEERS / PLANNERS ROCHESTER, N.H.

CLIENT Army Corps	JOB NO. 274-7901	PAGE	12 of 24
PROJECT St Pauls Pond Dam	COMPTD. BY BUP	DATE	2-22-80
DETAIL Hydrologic Calcs	CK'D. BY AMS	DATE	3/-/80

$STOR_4$ and $STOR_{AVG}$ agree to within about 2%. Therefore accept test flood discharge equal to 17,200 cfs at surcharge elevation equal to 337.0 feet

7. In Conclusion

a. Test flood discharge = 17,200 cfs will overtop spillway weir crest by 12 feet and the dam crest (top of training walls) by 6 feet

b. Overflow spillway capacity

(1) water surface at dam crest (top of training walls) - 331.0'

$$Q = (3.85)(100')(6.0')^{3/2} \approx 5660\,cfs$$

(2) water surface at test flood elevation - 337.0'

$$Q = (3.9)(100')(12.0')^{3/2} \approx 16,200\,cfs$$

c. Sluice gate capacity — includes discharge through 3.0' diameter sluicegate - (assume discharge through sluicegate not affected by discharge over spillway)

(1) water surface at dam crest - 331.0'

$$(a)\ Q_{sluicegate} = (0.6)(3.0)^2\pi\left[(2)(32.2)(331'-319.5')\right]^{1/2} \approx 430\,cfs$$

(2) water surface at test flood elevation 337.0

$$(a)\ Q_{sluicegate} = (0.6)(3.0)^2\pi\left[(2)(32.2)(337'-318.5')\right]^{1/2} \approx 595\,cfs$$

III. Using "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs examine impact of dam failure

1. Pertinent Data

a. Failure occurs when reservoir level at crest of dam - elevation = 331.0 feet

b. Storage at crest elevation estimated to be approximately 6,410 acre-ft

A. Reach 1

1. STEP 1: Determine reservoir storage at time of failure

from previous calcs. storage = 6,410 acre-ft

2. STEP 2: Determine Peak Failure Outflow Q_{P1}

a. $Q_{P1} = (8/27)\ W_b\ \sqrt{g}\ Y_o^{3/2}$

where: W_b = Breach width (use 40% of total length)
= (0.40) (100 feet)
= 40 feet

Y_o = Total height from channel bed to pool level at failure

Top of dam = 331.0'
Channel bottom = 316.0'
15.0'

Y_o = 15 feet

$Q_{P1} = (8/27)(40\ \text{feet})(32.2)^{1/2}(15.0\ \text{feet})^{3/2}$

Q_{P1} = 3,910 cfs

b. Since discharge over unfailed portion of spillway is significant must add this discharge to failure discharge

$Q_{P_{spillway}} = (3.85)(60\ \text{feet})(6\ \text{feet})^{3/2} \approx 3{,}390\ \text{cfs}$

c. $Q_{P1\,(TOTAL)}$ = 3,910 cfs + 3,390 cfs = 7,300 cfs

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CLIENT	Army Corps	JOB NO.	244-7901
PROJECT	[illegible] Dam	COMPTD. BY	BWP
DETAIL	Hydrologic Calcs.	CK'D. BY	[illegible]
PAGE	[illegible]	DATE	3.27.8[illegible]
		DATE	[illegible]

3. STEP 3: Prepare stage-discharge curve for Reach 1

a. Pertinent Data

(1) Reach length = 550 feet

(2) Channel slope = 0.019

(3) Manning n = 0.05

(4) Channel shape - trapezoidal ([illegible])

(5) Base width ≈ 30 feet

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P_1} = 7,300 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 6.2 feet

(2) Volume in reach = (reach length) $\begin{pmatrix}\text{cross-sectional}\\ \text{area of channel}\end{pmatrix}$

X-area = (0.5)(3.0')(30' + 120') + 0.5 (3.2')([illegible]' + [illegible])
= 643 ft²

$$\text{Volume} = V_1 = \frac{(643\ ft^2)(550\ ft)}{43\,560\ ft^2/acre}$$

= 8.1 acre-ft

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P2(TRIAL)}$

$$Q_{P2(TRIAL)} = Q_{P1}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P2(TRIAL)} = (7{,}300\ cfs)\left(1 - \frac{8.[illegible]}{64.[illegible]}\right)$$

$Q_{P2(TRIAL)}$ = 7,290 cfs

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c. Compute V_2 using $Q_{P2(TRIAL)}$

From Figure 3 determine stage for $Q_{P2(TRIAL)}$

Stage = [illegible] feet

X-area = 643 ft² (per above)

$$V_2 = \frac{(643\ ft^2)(550\ ft)}{43,560\ ft^2/acre}$$

V_2 = 8.1 acre-ft

d. Average V_1 and V_2 and compute Q_{P2}

(1) $V_{avg} = \dfrac{V_1 + V_2}{2}$

$$V_{avg} = \frac{8.1\ ac\text{-}ft + 8.1\ ac\text{-}ft}{2}$$

V_{avg} = 8.1 acre-ft

(2) $Q_{P2} = Q_{P1}\left(1 - \dfrac{V_{avg}}{S}\right)$

$$Q_{P2} = (7,300\ cfs)\left(1 - \frac{8.1}{640}\right)$$

Q_{P2} = 7,290 cfs

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PAGE	[illegible]	DATE	[illegible]
DATE	[illegible]		

B. Reach 2

1. STEP 3: Prepare stage-discharge curve for Reach 2

a. Pertinent Data

(1) Reach length = 500 feet

(2) Channel slope = 0.019

(3) Manning n = 0.05

(4) Channel shape - Trapezoidal (Side slopes not [illegible] compute x-area accordingly)

(5) Base width ≈ 30 feet

b. See Figure 3 for stage-discharge curve

2. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P2} = 7,290 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 5.8 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

X-area = (0.5)(4.0')(30' + 180') + (0.5)(.8')(180' − 245')
= 803 ft²

Volume = V_1 = $\frac{(803\ ft^2)(500\ ft)}{43,560\ ft^2/acre}$

= 9.2 ac-ft

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P3(TRIAL)}$

$$Q_{P3(TRIAL)} = Q_{P2}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P3(TRIAL)} = (7,290\ cfs)\left(1 - \frac{9.2}{6410}\right)$$

$$Q_{P3(TRIAL)} = 7,290\ cfs$$

c. Compute V_2 using $Q_{P3(TRIAL)}$

From Figure 3 determine stage for $Q_{P3(TRIAL)}$

Stage = 5.8 feet

X-area = 803 ft² (per above)

$$V_2 = \frac{(803\ ft^2)(500\ ft)}{43{,}560\ ft^2}$$

V_2 = 9.2 acre-ft

d. Average V_1 and V_2 and compute Q_{P3}

(1) $V_{avg} = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{9.2\ ac\text{-}ft + 9.2\ ac\text{-}ft}{2}$$

V_{avg} = 9.2 acre-ft

(2) $Q_{P3} = Q_{P2}\left(1 - \frac{V_{avg}}{S}\right)$

$$Q_{P3} = (7{,}290\ cfs)\left(1 - \frac{9.2}{6410}\right)$$

Q_{P3} = 7,280 cfs

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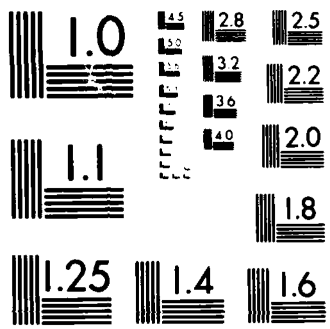

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C. Reach 3

1. <u>STEP 3:</u> Prepare stage-discharge curve for Reach 3

   a. Pertinent data

      (1) Since the pond in Reach 3 is created by a dam at its outlet, discharge from Reach 3 will be controlled by the dam.

      (2) discharge calculations over the dam spillway and abutment have been included at the end of the Hydrologic Calculations (Section II)

   b. see Figure 3 for stage discharge curve

2. <u>STEP 4:</u> Estimate Reach Outflow

   a. Determine stage for $Q_{P3} = 7,290$ cfs from Figure 3 and find volume in reach

      (1) Stage = 9.2 feet

      (2) Volume in reach = (Stage) $\left(\begin{matrix}\text{Average surface} \\ \text{area of pond *}\end{matrix}\right)$

      * see Figure 6 at end of Hydrologic Calcs

$$\text{Volume} = V_1 = (4.7\,\text{ft})\left(\frac{37.0\ \text{acres} + 42.0\ \text{acres}}{2}\right) + (4.5\,\text{ft})\left(\frac{42.0\ \text{acres} + 51.0\ \text{acres}}{2}\right)$$

$$V_1 = 395\ \text{ac-ft}$$

$V_1 < \frac{S}{2}$ ∴ [illegible] OK

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b. Determine $Q_{P4 \text{ (TRIAL)}}$

$$Q_{P4(TRIAL)} = Q_{P3}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P4(TRIAL)} = (7{,}280 \text{ cfs})\left(1 - \frac{395}{6410}\right)$$

$$Q_{P4(TRIAL)} = 6{,}830 \text{ cfs}$$

c. Compute V_2 using $Q_{P4(TRIAL)}$

From Figure 3 determine Stage for $Q_{P4(TRIAL)}$

STAGE = 8.9 feet

$$V_2 = (4.7 \text{ ft})\left(\frac{37.0\text{ac} + 42.0\text{ac}}{2}\right) + (4.2 \text{ ft})\left(\frac{42.0\text{ac} + 50.5\text{ac}}{2}\right)$$

$$V_2 = 380 \text{ acre-ft}$$

d. Average V_1 and V_2 and compute Q_{P4}

(1) $$V_{avg} = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{395\text{ac-ft} + 380\text{ac-ft}}{2}$$

$$V_{avg} = 387 \text{ acre-ft}$$

(2) $$Q_{P4} = Q_{P3}\left(1 - \frac{V_{avg}}{S}\right)$$

$$Q_{P4} = (7{,}280 \text{ cfs})\left(1 - \frac{387}{6410}\right)$$

$$Q_{P4} = 6{,}840 \text{ cfs}$$

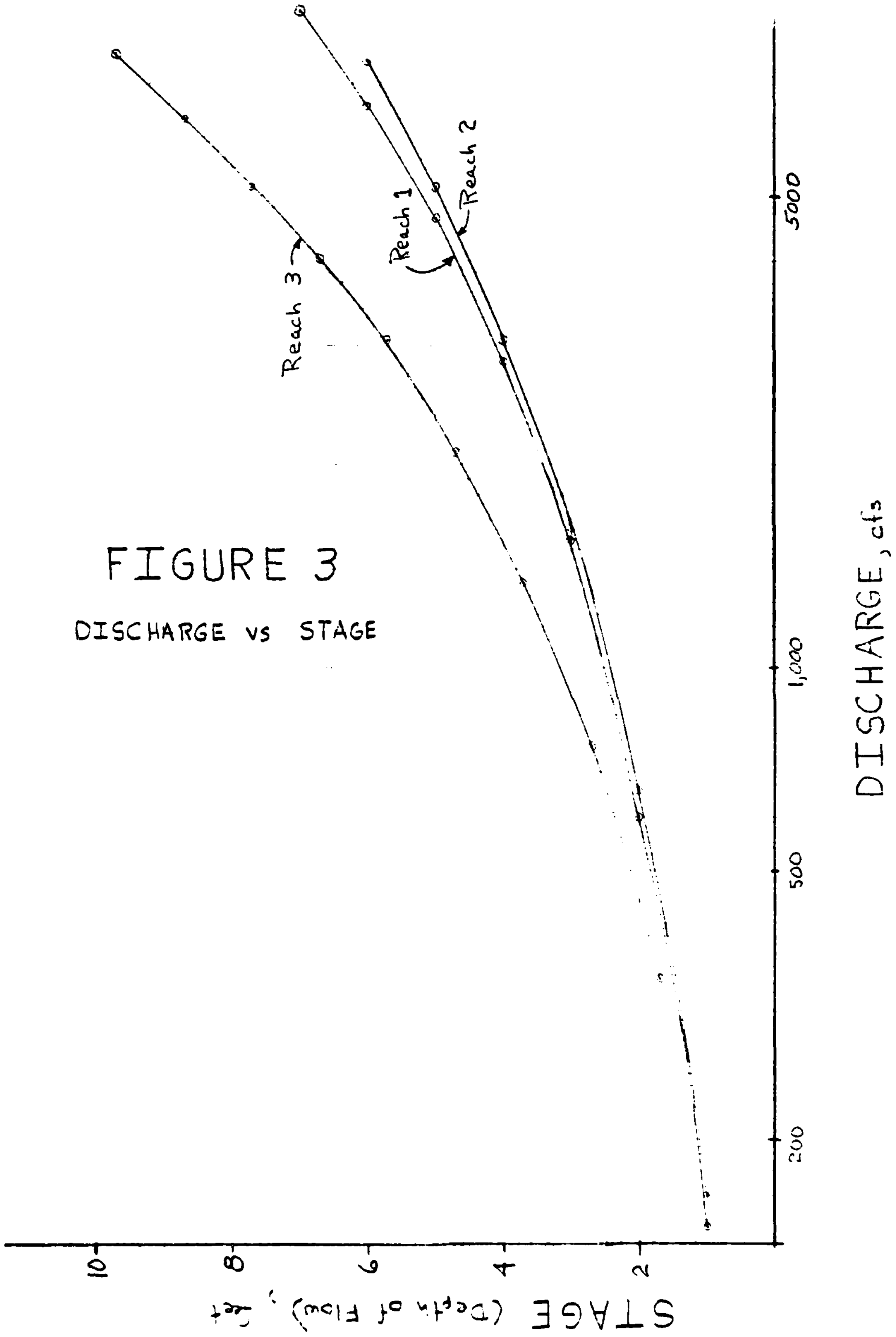

FIGURE 3

DISCHARGE vs STAGE

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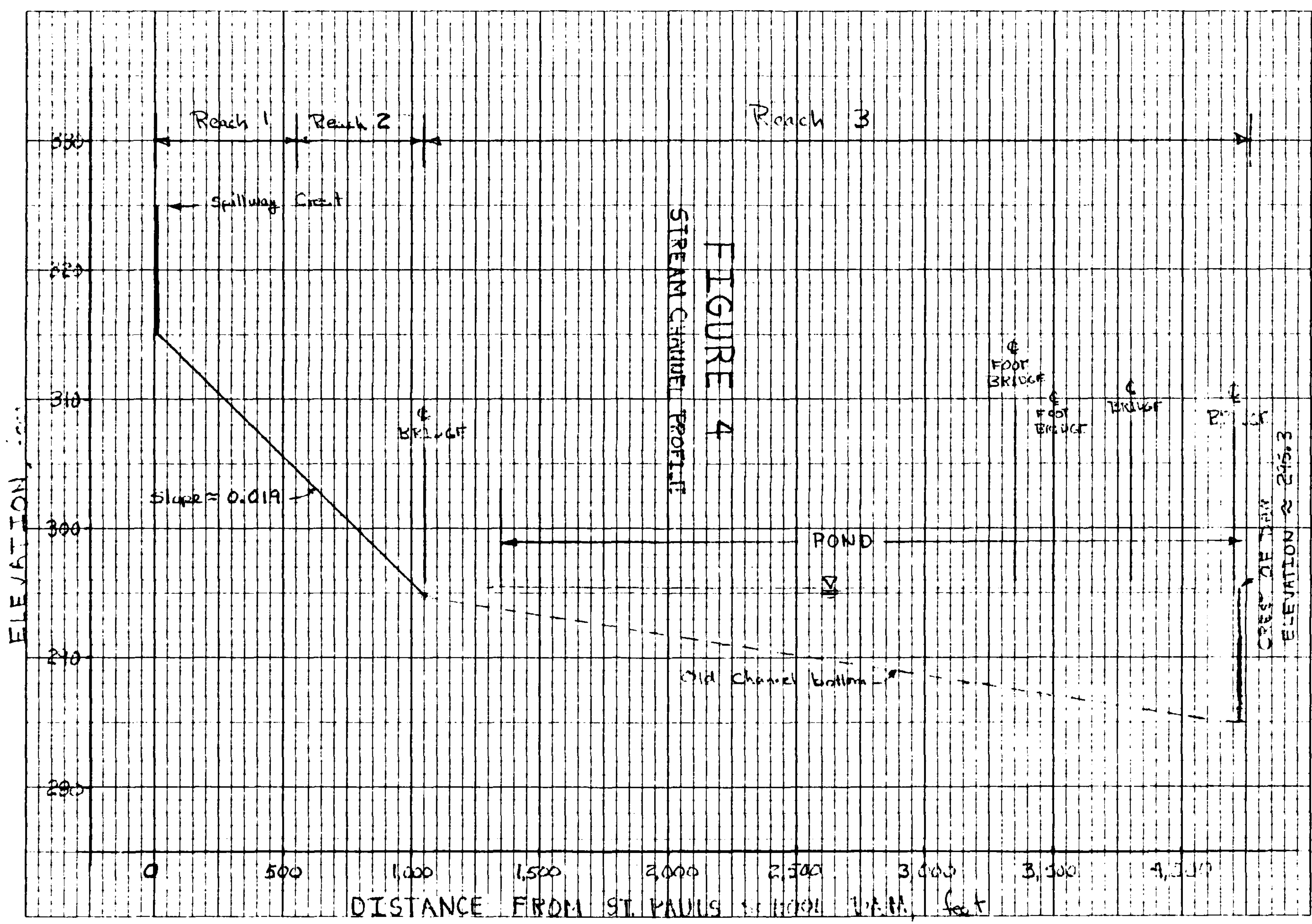

FIGURE 4
STREAM CHANNEL PROFILE

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IV. Compare dam failure discharge stage to stage resulting from discharge over spillway with water surface at the crest of dam. (elevation 331.0)

A. Since the spillway length extends almost the entire length of the dam, the discharge over the spillway will be quite large. Therefore the stage resulting from the spillway discharge with water surface at the crest of dam must be compared to the stage for the failure discharge determined in Section III.

1. From previous calculations (p3 of the Hydrologic Calcs) the discharge over the spillway with water surface at crest of dam was computed to be 5,660 cfs

2. Since the critical area is at the lower pond compare the stage of this discharge to that for the ... discharge, Q_{P4}, for Reach 3 in Section II of these calcs.

a. Stage for 5,660 cfs (from Figure 3) = 8.1 feet

b. Stage for Q_{P4} = 6,840 cfs is 9.0 feet

3. Conclusion -

a. The failure of the dam with the water surface at the dam crest will result in only a 0.9 foot increase over the stage of the prefailure discharge in the lower ponding area. Therefore will consider the failure of the dam with water surface at the spillway crest in order to assess the hazard classification of this dam

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V Using "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs examine impact of dam failure with water surface at spillway crest

1. Pertinent Data

   a. Failure occurs when reservoir level at crest of spillway [redacted] - elevation = 325.0'

   b. Storage at crest elevation estimated to be approximately 700 acre-feet

A. Reach 1

1. STEP 1: Determine reservoir storage at time of failure

   from previous calcs. storage = 700 acre-ft

2. STEP 2: Determine Peak Failure Outflow Q_{P1}

$$Q_{P1} = (8/27)\ W_b\ \sqrt{g}\ Y_o^{3/2}$$

where: W_b = Breach width (use 40% of total length)
= (0.40)(100 feet)
= 40 feet

Y_o = Total height from channel bed to pool level at failure

Spillway crest = 325.0
Channel bottom = 316.0
9.0

= 9.0'

$$Q_{P1} = (8/27)(40\text{ feet})(32.2)^{1/2}(9.0')^{3/2}$$

$$Q_{P1} = 1{,}820\text{ cfs}$$

3. STEP 3: Prepare stage-discharge curve for Reach 1

a. Pertinent Data

(1) Reach length = 550 feet

(2) Channel slope = 0.019

(3) Manning n = 0.05

(4) Channel shape - trapezoidal (side slopes not consistent - compute x-area accordingly)

(5) Base width ≈ 30 feet

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P1} = 1,820 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 3.3 feet

(2) Volume in reach = (reach length) $\begin{pmatrix}\text{cross-sectional}\\ \text{area of channel}\end{pmatrix}$

$$\text{X-area} = (0.5)(3.0')(30' + 120') + (0.5)(0.3)(120' - 33')$$
$$= 261 \text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(261 \text{ ft}^2)(550 \text{ ft})}{43{,}560 \text{ ft}^2/\text{acre}}$$

$$= 3.3 \text{ acre-ft}$$

$$V_1 < \frac{S}{2} \quad \therefore \text{reach length OK}$$

b. Determine $Q_{P2(TRIAL)}$

$$Q_{P2(TRIAL)} = Q_{P1}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P2(TRIAL)} = (1{,}820 \text{ cfs})\left(1 - \frac{3.3 \text{ acre-ft}}{700}\right)$$

$$Q_{P2(TRIAL)} = 1{,}810 \text{ cfs}$$

c. Compute V_2 using $Q_{P2(TRIAL)}$

From Figure 3 determine stage for $Q_{P2(TRIAL)}$

Stage = 3.3 feet

X-area = 261 ft² (per above)

$$V_2 = \frac{(261\ ft^2)(550\ ft)}{43,560\ ft^2/acre}$$

V_2 = 3.3 acre-ft

d. Average V_1 and V_2 and compute Q_{P2}

(1) $$V_{avg} = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{3.3\ acre\text{-}ft + 3.3\ acre\text{-}ft}{2}$$

Vavg = 3.3 acre-ft

(2) $$Q_{P2} = Q_{P1}\left(1 - \frac{V_{avg}}{S}\right)$$

$$Q_{P2} = (1,820\ cfs)\left(1 - \frac{3.3}{700}\right)$$

Q_{P2} = 1,810 cfs

B. Reach 2

3. STEP 3: Prepare stage-discharge curve for Reach 2

a. Pertinent Data

(1) Reach length = 500 feet

(2) Channel slope = 0.019

(3) Manning n = 0.05

(4) Channel shape - trapezoidal

(5) Base width ≈ 30 feet

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P2} = 1810 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 3.1 feet

(2) Volume in reach = (reach length) $\begin{pmatrix}\text{cross-sectional}\\\text{area of channel}\end{pmatrix}$

$$\text{X-area} = (0.5)(3.1\text{ ft})(30\text{ ft} + 150\text{ ft})$$
$$= 279\text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(279\text{ ft}^2)(500\text{ ft})}{43{,}560\text{ ft}^2/\text{acre}}$$

$$= 3.2\text{ acre-ft}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P3(TRIAL)}$

$$Q_{P3(TRIAL)} = Q_{P2}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P3(TRIAL)} = (1{,}810\text{ cfs})\left(1 - \frac{3.2}{200}\right)$$

$$Q_{P3(TRIAL)} = 1{,}800\text{ cfs}$$

c. Compute V_2 using $Q_{P3(TRIAL)}$

From Figure 3 determine stage for $Q_{P3(TRIAL)}$

Stage = 3.1 feet

X-area = 279 ft² (per above)

$$V_2 = \frac{(279\ ft^2)(500\ feet)}{43{,}560\ ft^2/acre}$$

$$V_2 = 3.2\ acre\text{-}ft$$

d. Average V_1 and V_2 and compute Q_P

(1) $$V_{avg} = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{3.2\ acre\text{-}ft + 3.2\ acre\text{-}ft}{2}$$

$$V_{avg} = 3.2\ acre\text{-}ft$$

(2) $$Q_{P3} = Q_{P2}\left(1 - \frac{V_{avg}}{S}\right)$$

$$Q_{P3} = (1{,}810\ cfs)\left(1 - \frac{3.2}{700}\right)$$

$$Q_{P3} = 1{,}800\ cfs$$

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C. Reach 3

1. STEP 3: Prepare stage-discharge curve for Reach 3

a. Pertinent data

(1) Since the pond in Reach 3 is created by a dam at its outlet, discharge from Reach 3 will be controlled by the dam

(2) discharge calculations over the dam spillway and abutment have been included at the end of the Hydrologic Calculation.

b see Figure 3 for stage discharge curve

2. STEP 4: Estimate Reach Outflow

a Determine stage for $Q_{p3} = 1,800$ cfs from Figure 3 and find volume in reach

(1) Stage = 4.4 feet

(2) Volume in reach = (Stage)(Average surface area of pond *)

* see Figure 6 at end of Hydrologic Calcs

$$\text{Volume} = V_1 = (4.4 \text{ feet}) \left(\frac{37.0 + 41.5}{2} \right)$$

$$V_1 = 173 \text{ acre-ft}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

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b. Determine $Q_{P4(TRIAL)}$

$$Q_{P4(TRIAL)} = Q_{P3}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P4(TRIAL)} = (1{,}800\text{ cfs})\left(1 - \frac{173}{700}\right)$$

$$Q_{P4(TRIAL)} = 1360\text{ cfs}$$

c. Compute V_2 using $Q_{P4(TRIAL)}$

From Figure 3 determine stage for $Q_{P4(TRIAL)}$

STAGE = 3.7 feet

$$V_2 = (3.7\text{ feet})\left(\frac{37.0\text{ acres} + 41.0\text{ acres}}{2}\right)$$

$$V_2 = 144\text{ acre-ft}$$

d. Average V_1 and V_2 and compute Q_{P4}

(1) $V_{avg} = \dfrac{V_1 + V_2}{2}$

$$V_{avg} = \frac{173\text{ acre-ft} + 144\text{ acre-ft}}{2}$$

$$V_{avg} = 159\text{ acre-ft}$$

(2) $Q_{P4} = Q_{P3}\left(1 - \dfrac{V_{avg}}{S}\right)$

$$Q_{P4} = (1{,}800\text{ cfs})\left(1 - \frac{159}{700}\right)$$

$$Q_{P4} = 1{,}390\text{ cfs}$$

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III Stage-discharge calculations – lower pond (Reach 3)

1. Discharge over dam crest

Elevation feet	C	L feet	H feet	Q cfs
295.3	—	—	0	0
296.0	2.8	32	0.7	52
297.0	3.3	↓	1.7	234
298.0	↓	↓	2.7	468
299.0	↓	↓	3.7	752
300.0	↓	↓	4.7	1080
301.0	↓	↓	5.7	1440
302.0	↓	↓	6.7	1830
303.0	↓	↓	7.7	2260
304.0	↓	↓	8.7	2710
305.0	↓	↓	9.7	3190

2. Discharge over right abutment

a. between dam and building

Elevation (feet)	C	L (feet)	avg. H feet	Q cfs
295.3	—	—	0	0
296.0	2.6	18	0.35	10
297.0	↓	25	0.85	5[illegible]
298.0	↓	↓	1.35	102
299.0	↓	↓	1.85	164
300.0	↓	↓	2.35	234
301.0	↓	↓	2.85	313
302.0	↓	↓	3.35	399
303.0	↓	↓	3.85	491
304.0	↓	↓	4.35	590
305.0	↓	↓	4.85	694

2. between building and points further up slope

Elevation (feet)	C	L (feet)	avg H (feet)	Q (cfs)
300.0	—	—	0	0
301.0	2.6	20	0.4	13
302.0	↓	48	0.9	107
303.0	↓	75	1.4	330
304.0	↓	105	1.9	715
305.0	↓	133	2.4	1290

3 Discharge over left abutment

Elevation (feet)	C	L (feet)	avg H (feet)	Q (cfs)
295.3	—	—	—	—
296.0	2.6	10	0.35	5
297.0	↓	30	0.85	61
298.0	↓	49	1.35	196
299.0	↓	65	1.85	425
300.0	↓	83	[illegible]	777
301.0	↓	103	2.85	1290
302.0	↓	105	3.35	1670
303.0	↓	105	[illegible]	2060
304.0	↓	105	4.35	2490
305.0	↓	105	4.85	2920

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4. Total discharge from lower pond [illegible] to [illegible]

Stage ft	Elevation feet	Q dam crest	Q right abut - dam to slide	Q right abut - slide to [illegible]	Q left abut	Q TOTAL
0	295.3	0	0	0	0	0
0.7	296.0	52	10	0	5	67
1.7	297.0	234	51	0	61	346
2.7	298.0	468	102	0	196	766
3.7	299.0	752	164	0	425	1340
4.7	300.0	1080	234	0	[illegible]	2090
5.7	301.0	1440	313	13	[illegible]	3060
6.7	302.0	1830	399	107	[illegible]	4010
7.7	303.0	2260	491	336	[illegible]	5150
8.7	304.0	2710	590	715	[illegible]	6500
9.7	305.0	3190	694	1240	[illegible]	8090

FIGURE 5

CROSS-SECTION PROFILE

(Looking upstream)

LOWER POND OUTLET (REACH 3)

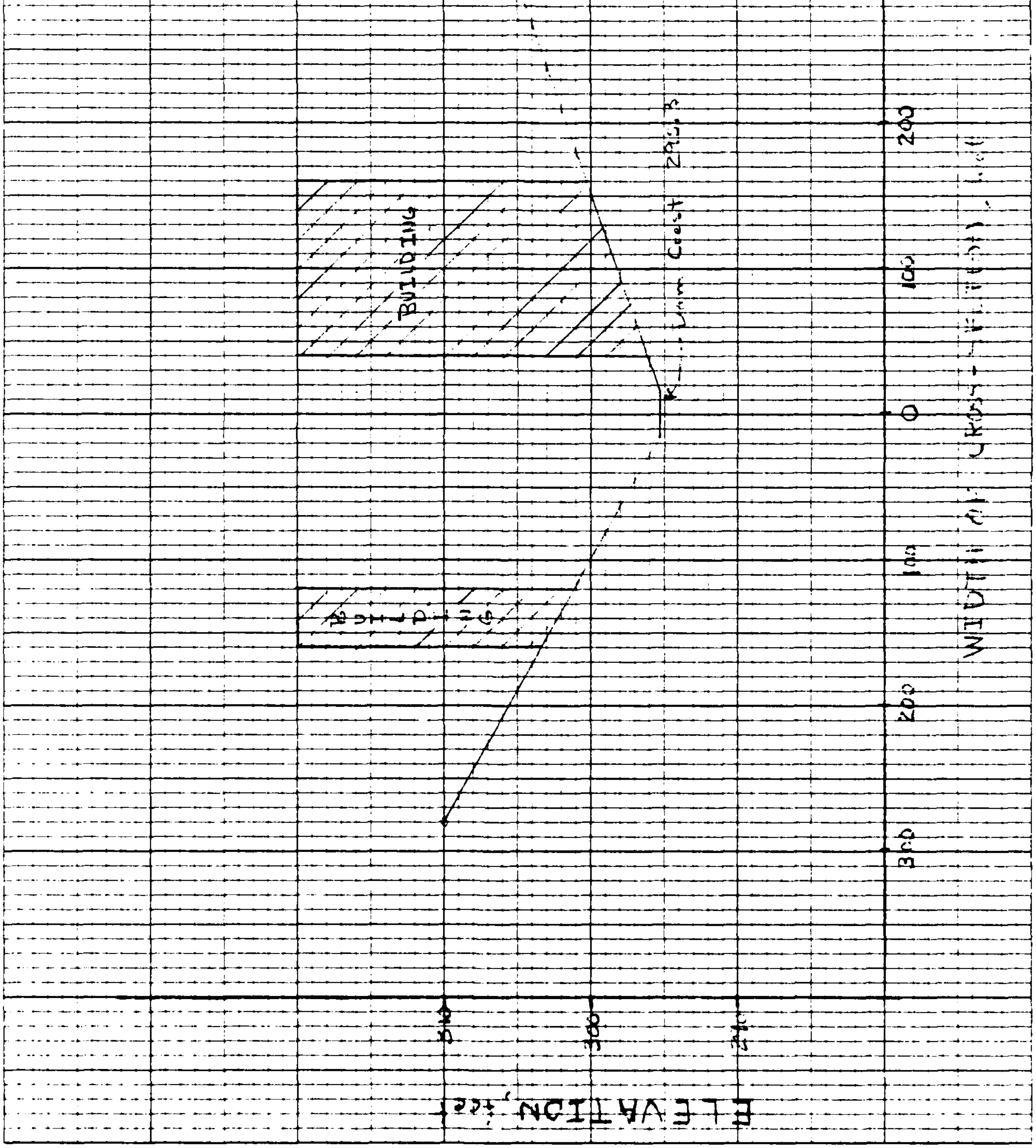

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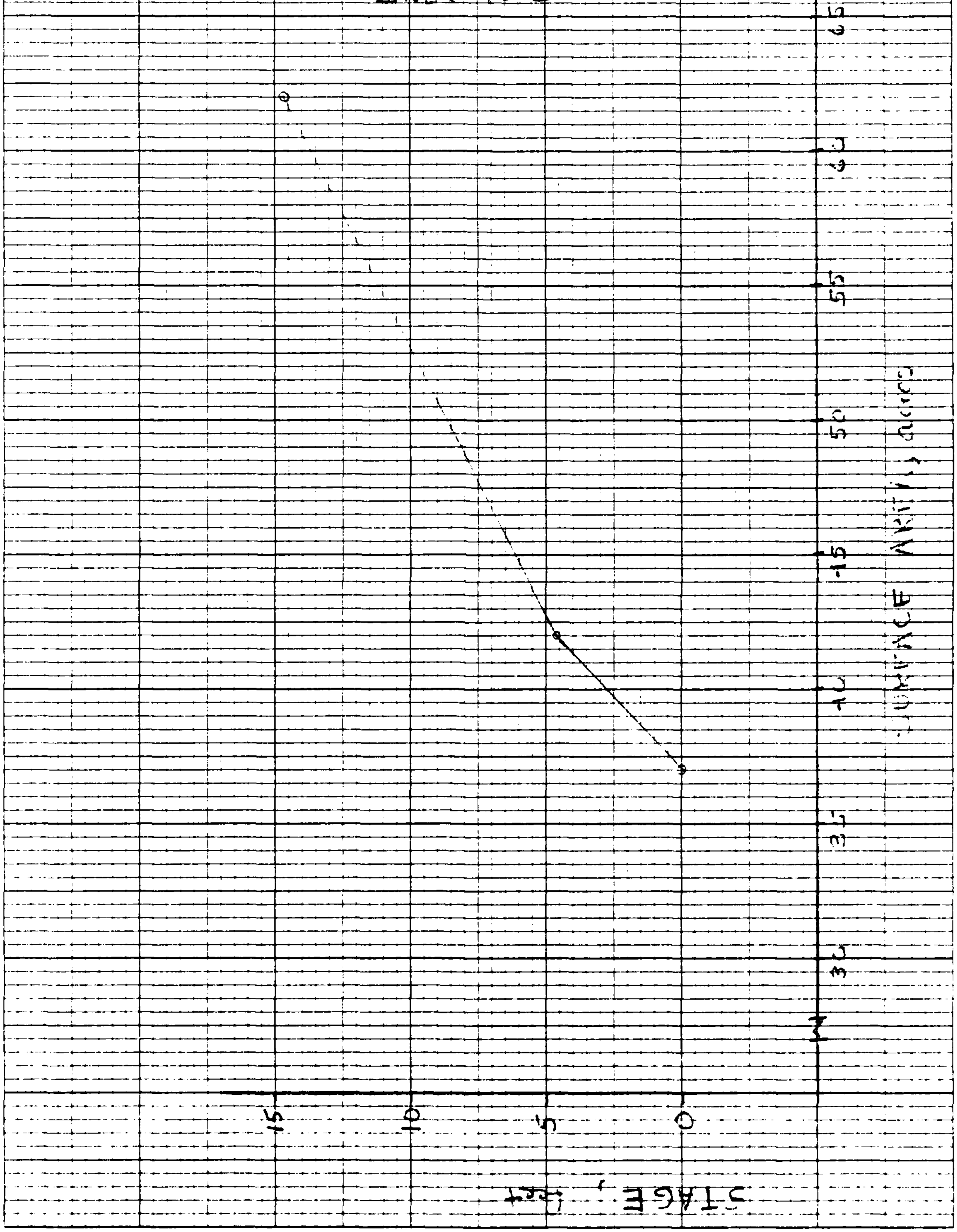
FIGURE 6

SURFACE AREA VS STAGE
LOWER POND



APPENDIX E

INFORMATION AS CONTAINED IN THE
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